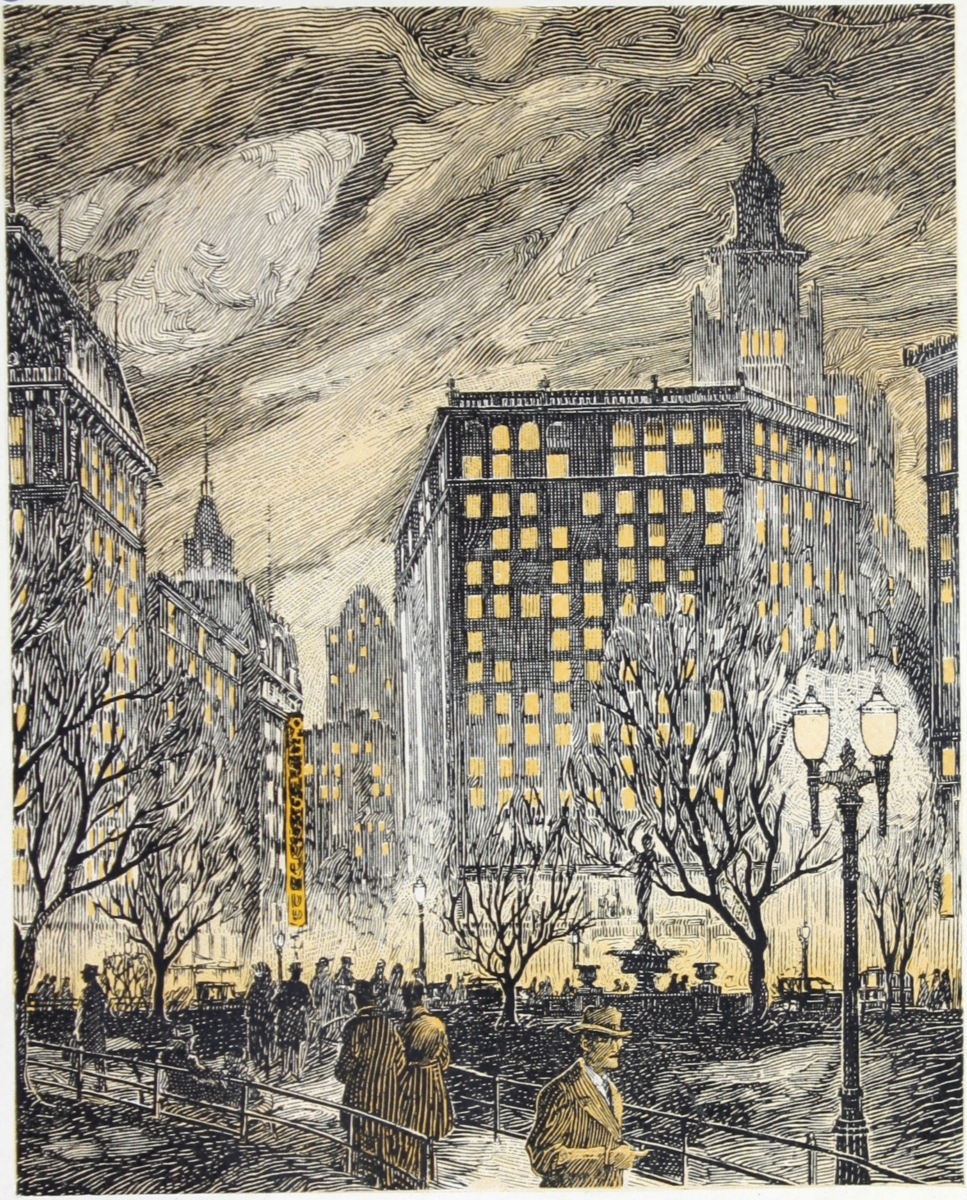


Street Lighting with MAZDA Lamps

EDISON LAMP WORKS
OF GENERAL ELECTRIC COMPANY

GENERAL SALES OFFICE
HARRISON, N. J.

Where Visitors to the Institute Are Received

Model Store of the Institute

Industrial Lighting Room

At the Edison Lighting Institute, dedicated to the public for the advancement of the art and science of illumination in its many and varied applications, are portrayed most dramatically hundreds of uses of light.

Street Lighting with MAZDA Lamps

Information Compiled by
T. P. BROWN
Engineering Department

In the larger cities of the country may be found indications of very gratifying progress toward higher standards of illumination. A visitor to the city of Indianapolis, Ind., realizes that careful thought has been given to the lighting of Washington Avenue, which is seen on the left in this illustration. At the right of the intersection Virginia Avenue presents a vista of brightly illuminated thoroughfare. For the lighting equipment G-E Form 9 ornamental Novalux units with No. 118 globes and No. 1118 canopies are used throughout.

SYNOPSIS | PAGE

For information regarding MAZDA lamps and lighting questions, refer to the nearest sales office.

To insure receipt of bulletins, notify the Department of Publicity, Edison Lamp Works of General Electric Company, Harrison, N. J., of any change of address.

An excellent example of modern street lighting practice—Springfield Avenue at Branford Place, Newark, N. J.

In the smaller cities and towns may be found adequately lighted thoroughfares in marked contrast to the conditions which prevailed but a short time ago. This view, taken in Mamaroneck, N. Y., gives an idea of the excellent appearance of many of our progressive towns.

Purpose of Street Lighting

A person particularly interested in prevention of crime would probably say that the prime purpose of street lighting is reduction of crime. Likewise, one who would vision an age of no traffic accidents and maximum utilization of our street surface, would claim that facilitation of traffic is the real reason for street lighting. It all depends upon the point of view. We can say, though, that eliminating the personal point of view, the purposes underlying modern street lighting are:

1. Protection of Life and Property

Tests have been conducted showing that modern street lighting is really a deterrent to crime. After a high intensity white way system of lighting was installed on the main business street in Cleveland a decrease of 8 per cent was observed in the number of crimes at a time when on the less well lighted streets there was an increase of 57 per cent. Without question, therefore, modern street lighting is of real value in preventing and detecting crime.

2. Facilitation of Traffic

Concerning traffic, this age is one of speed—our automobiles are running at speeds which are far in excess of those of the horse-drawn vehicles of our forefathers. This rate of travel being taken for granted, it is obvious that there must be street illumination of sufficiently high order to enable us to perceive objects on the road and act before disaster overtakes us. As an indication that lack of sufficient illumination on streets is dangerous, it has been proved from statistics that approximately 18 per cent of the deaths in 1920 due to traffic at night could have been eliminated if adequate street lighting had been available. Statistics tell us that we are paying considerably more money as a result of accidents and deaths in traffic, than we are in attempting to reduce these losses.

3. Civic Pride and Publicity

The average individual takes pride in anything that he does well, or in anything with which he is associated that functions well. He is proud of himself—he dresses well. He is proud of his home—he invites his friends to visit him. He is proud of his business when

it goes well. He is proud of his city—when it permits or compels a favorable reaction. One of the features of a good street lighting installation is that it fosters the spirit of civic pride. The individual, rather than being a knocker or only passively interested, is an active booster for the town. Good street lighting is an indication of progress. Every small municipality aspires to be a city. Well lighted streets are the first step in the march of progress. Well lighted highways lead visitors to the town; good lighting on the

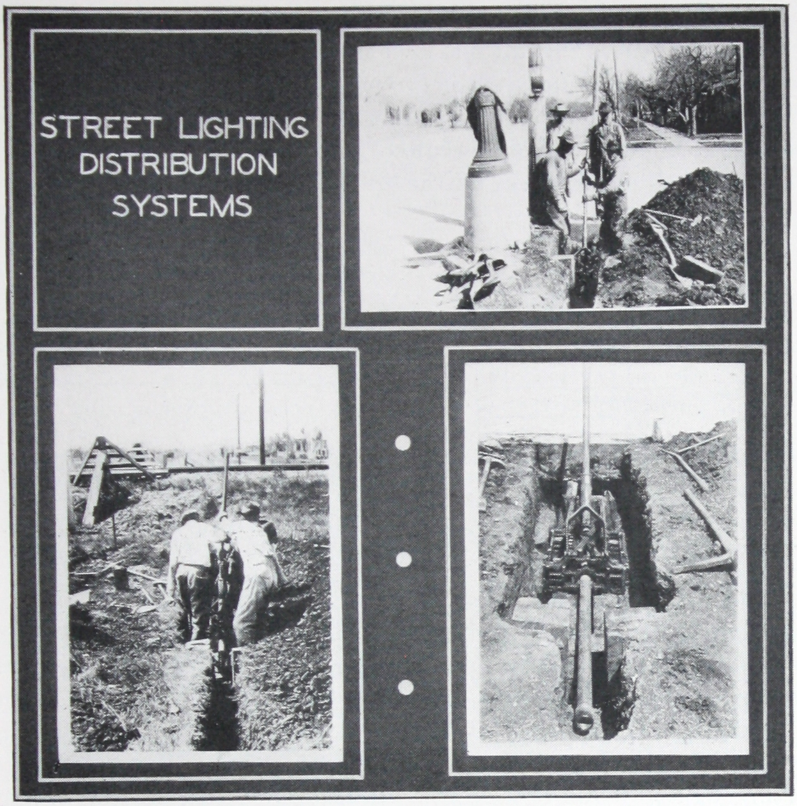
The appearance of a town is greatly enhanced by well lighted boulevards. The favorable impression upon a motorist entering East Orange, N. J., by its well known Park Avenue, may readily be imagined.

residential streets invites these visitors to become residents; well illuminated business streets show the visitors that prosperity prevails and they stop to make purchases.

Modern street lighting causes a feeling of contentment and pride to exist among the residents, and provides one more point which may be emphasized in advertising the town and extolling its virtues.

4. Aid to Merchants

A merchant in order to be successful must sell merchandise. In order to do this he must attract people into the store. This is done by means of attention-getting and interest-compelling window displays for the people on the sidewalk. But, how can he be sure that people will be on the sidewalk in the vicinity of his store unless there is adequate street lighting to attract them?



SERIES SYSTEMS

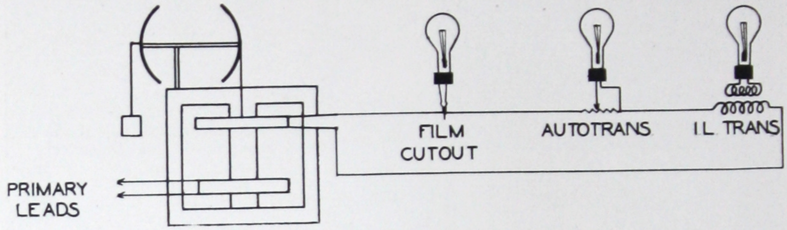
There are two general types of street lighting distribution systems in use at the present time, series and multiple.

General Characteristics of Series Systems

Nearly all of the series systems are now energized by alternating current, furnished and held at rated amperes by constant current transformers. The line current flows successively through each lamp of the circuit, or, where local current transformers or auto-transformers are used, through the primary coils so that the same line current passes through each unit, as contrasted with the subdivision of the current obtained in a multiple system. The line current must therefore be maintained at its rated value. (See Bulletin LD-152, *Modern and Obsolete Street Lighting Systems*.)

Necessarily, if the line circuit should be broken at any point, all of the lamps on that circuit would be extinguished. Where

lamps are operated directly on the line circuit, it is universal practice to provide a cut-out, as a shunt across each lamp, so that whenever a lamp failure tends to open the circuit the voltage impressed upon an insulating film punctures the film. In this manner the lamp is merely short circuited, and electrical supply is maintained for all other lamps on the circuit.



Schematic diagram of a simple series system. Provision must be made so that when a lamp fails, the circuit will maintain its continuity. In the film cutout, the film is punctured due to the high momentary voltage across the filament. In the case of the auto-transformer or the IL transformer, failure of the lamp does not affect the circuit.

Obviously a series circuit is separate and distinct from other circuits; it can, therefore, be turned on or off at any time independently of other loads. For any series circuit the load voltage or operating voltage required will depend upon the number and size of lamps, and resistance of the cable. In general, this voltage is quite high, running from approximately 750 volts for a 5-kilowatt rating to approximately 10,500 volts for a 70-kilowatt constant current transformer. The open circuit voltage is approximately 20 to 35 per cent greater than the normal load voltage.

Characteristics of Lamps Used in Series Systems

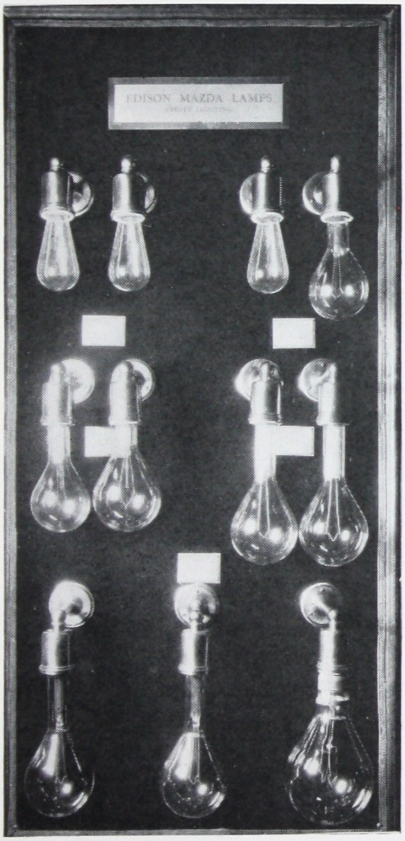
Inasmuch as there is a constant current flowing continuously through a series circuit, it is essential that the lamps used be built especially for this purpose. These lamps in general are of the gas-filled type, having filaments manufactured to close specifications as regards current capacity. This is in contrast to multiple lamps in which the specifications emphasize voltage accuracy. Series lamps are sensitive to variations in current, which produce magnified variations in light output or burning life of lamps. (See Bulletin LD-152.) Due to the fact that, as the filament vaporizes and deposits on the bulb (causing blackening), its diameter gradually decreases, offering higher resistance to the current and hence generating more light to offset the blackening effects. Therefore, lamps for direct operation on series circuits give approximately

100 per cent rated initial light throughout life. In the high current series lamps, such as are operated on current transformers, the gradual reduction in diameter of filament is not sufficient to offset completely the blackening of the bulb; and, as a result, the mean lumens are slightly less than the average initial lumens. Series lamps have a nominal life of 1350 hours, and are rated in amperes and lumens. It is almost universal practice to use a 6.6-ampere circuit for series street lighting. The following sizes of lamps are furnished at this current rating:

600, 800, 1000, 2500, 4000, and 6000 lumens.

If auto-transformers or IL transformers are installed in the circuit, it is possible to obtain either 15 or 20 amperes from the secondary taps, in which case the following sizes of lamps are available:

4,000 lumens, 15 ampere.
6,000 lumens, 20 ampere.
10,000 lumens, 20 ampere.
15,000 lumens, 20 ampere.
25,000 lumens, 20 ampere.



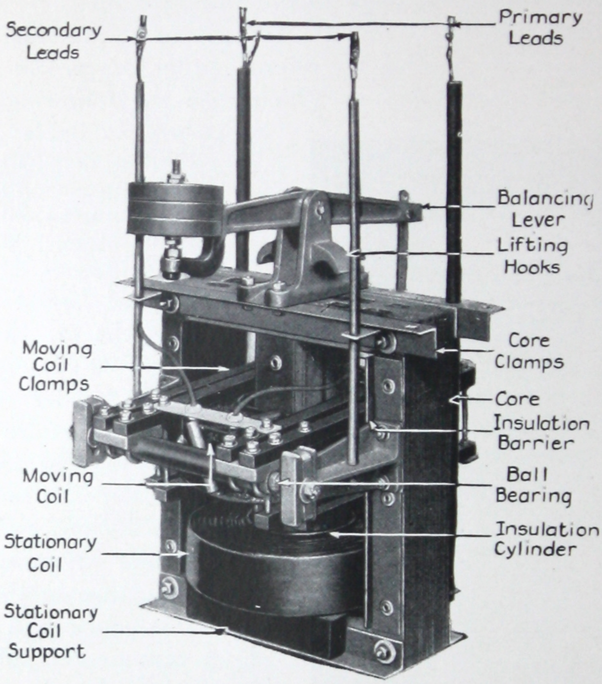
Types of lamps used on series circuits, as shown at the Edison Lighting Institute.

For large street lighting units it is the practice to use the 15- and 20-ampere MAZDA lamps; for smaller units the 6.6-ampere lamps are preferable. In the intermediate range the choice depends largely upon local conditions, each having its particular advantage. A distinct advantage in the use of an IL Transformer in the base of an ornamental pole is the elimination of high voltage in the leads extending to the lamp. The danger from open circuit conditions is greatly reduced—inasmuch as the only leads in the pole are the ones from the IL Transformer—which has a very much lower open circuit voltage than a constant current transformer. Where bracket pendent fixtures

are used, the IL Transformer is placed on the line pole with the secondary leads running to the lamp. In this way the main circuit is not opened by breakage or loosening of the leads to the lamp. Film cutouts are of course unnecessary where the current transformer is employed.

Characteristics of Transformers, Cable, Etc., for Series Systems

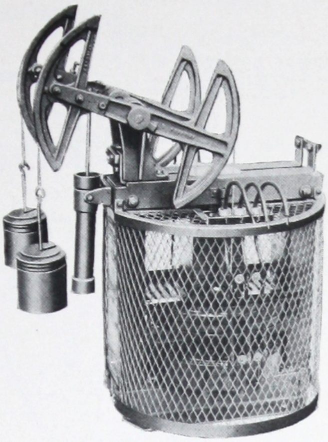
The constant current transformer supplying a series circuit may be either automatic or non-automatic as to starting. The



Interior view of a pole type automatic constant current transformer. This apparatus requires no attendant for starting due to the high reactance of the coils.

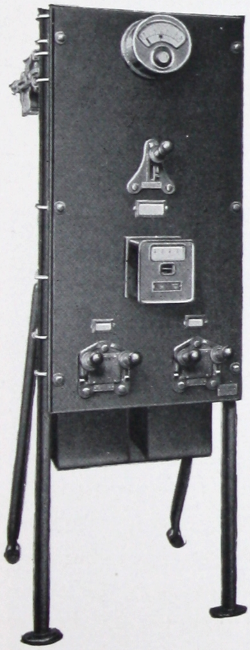
automatic type is furnished for station, pole or subway installations; the non-automatic type being furnished only for use in stations, since it requires the presence of an attendant to see that the coils are locked apart at starting. The automatic type may be miles away from the operator. This is possible because of the higher reactance of the automatic type which tends to "choke" the starting current in the secondary coil, preventing it from being

excessive. For a detailed treatise on the theory of these transformers the reader is referred to Bulletin LD-152 or any recognized electrical engineering textbook.



View of a station type constant current transformer. This apparatus requires an attendant for starting.

The IL Transformer serves the double purpose of transforming the current from the line amperage to that of the lamp, and of providing insulation—the primary and secondary coils being entirely separate. IL transformers with a 1:1 ratio may be used in order to insulate the lamp and the leads from the high voltage series circuit. The auto-transformer, because of its electrical construction, does not provide such insulation.



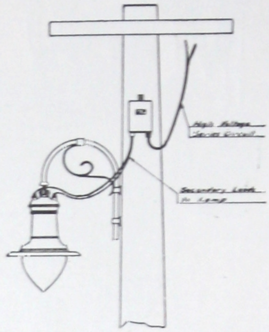
Panel for operating station type constant current transformers.

Two sizes of wire are commonly used for series circuits—depending on installation conditions. If overhead distribution is employed, No. 6 triple braid, weatherproof wire is used. This wire has a No. 6 A.W.G. copper conductor with an insulation consisting of three braids impregnated with black weatherproof compound. For underground installations the common practice tends toward No. 8 cable, either of the lead covered or band steel armored type. Of course it is essential that mechanical protection, as well as electrical insulation, be provided for the copper conductor. In the "parkway" cable the band steel armor has been considered sufficient protection. Where lead sheath is used, an additional factor of safety is sometimes provided by drawing this cable in conduit or iron pipes (particularly at street intersections). Inasmuch as the operating voltage of a circuit increases with the size of the constant

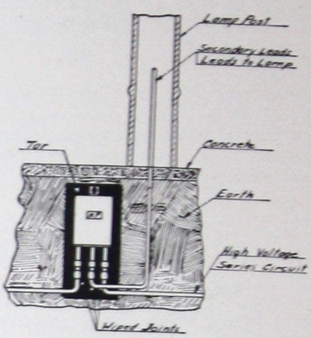
NOVALUX SERIES TRANSFORMERS

TYPE IL

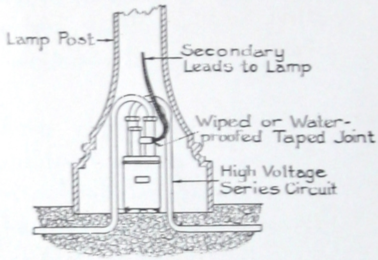
METHODS OF MOUNTING



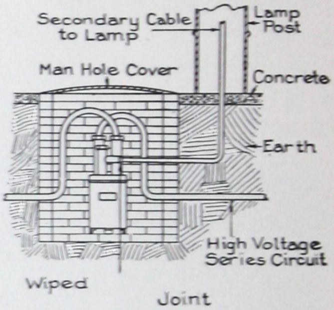
Installation of IL Transformer
Aerial Type



Series Transformer Buried in Ground

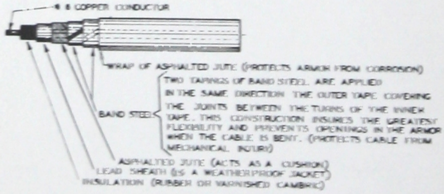


Installation of IL Transformer
in Base of Ornamental Pole

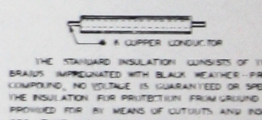


Installation of IL Transformer
in Manhole

current transformer, it is necessary that the underground cable be insulated from ground to a degree at least equal to the operating voltage of the constant current transformer serving it. The following



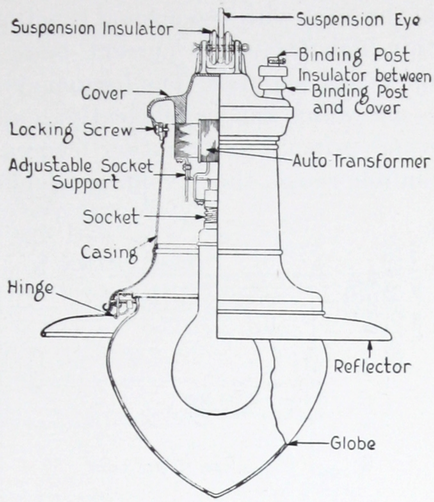
Detail of No. 8 parkway cable, used for underground street lighting circuits.



No. 6 T.B.W.P. wire, commonly used for aerial street lighting circuits.

are the standard insulating voltages for lead sheath or "parkway" cable:

600, 2500, 3500, 5000, and 8000 volts.



Mounting of auto-transformer in lamp casing. This casing may readily be removed for examination of the interior assembly.

Control of Series Circuits

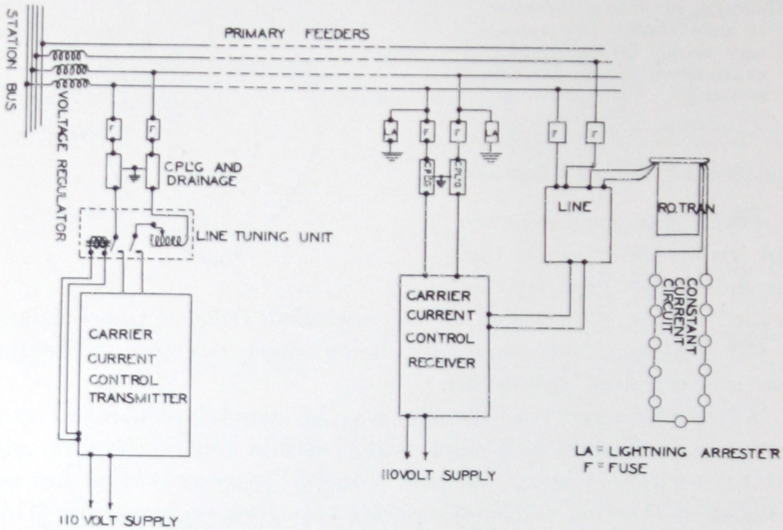
Where the constant current transformer is of the non-automatic type and is located in the substation, it is controlled from a panel board in the building, the secondary being short circuited while the primary is being connected.

Automatic series transformers may be remotely controlled by a carrier current device, a pilot wire, cascade control, or a remote control switch. Carrier current control represents the newest method of starting automatic series transformers remotely. This system has been designed to permit the control of automatic constant current transformers of the pole type from attendant substations, distributing power over the usual 2300- or 4000-volt circuits. In general, it gives the equivalent of pilot wire control without the use of pilot wires.

In the pole type unit the auto-transformer is mounted beneath the receptacle and lamp. The entire unit may be easily disassembled.

The operation of the system depends primarily upon the fact that a high frequency current can be transmitted over the power wires without interfering

in the least with the normal functioning of the distribution system, this high frequency current being the "carrier" of the receiver operating impulses. The frequency selected for this type of control is one which can be efficiently generated and transmitted over the usual primary distribution feeders. This frequency is above the audible range, thus avoiding telephone interference, and below the



Schematic diagram of carrier current control.

frequencies which would cause interference with carrier current communication sets, radio broadcasts, or other space radio services. The accompanying figure shows schematically how the equipment is arranged for the control of a single receiver over a distribution feeder. The control transmitter, which is generally located at an attended substation, is connected to two phase wires of the feeder on the line side of the voltage regulators through a tuning unit, coupling capacitors, and fuses. At the control point the receiver is connected to the line through fuses and capacitors. When an impulse of definite frequency and time duration is sent out by the transmitter, it is picked up by the receiver which operates the line contactor, closing the circuit on the primary of the transformer and turning on the lights. Another impulse of definite frequency and different time interval will reverse operations—opening the primary circuit of the transformer and turning off the lamps. It should be

SERIES SYSTEM

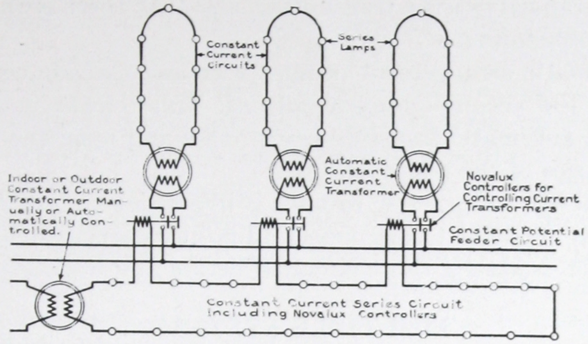


Diagram Showing how Several Type RO Transformers can be Controlled by Series Controllers Placed in a Series Lighting Circuit Which Also Acts as a Control Circuit

CASCADE SYSTEM

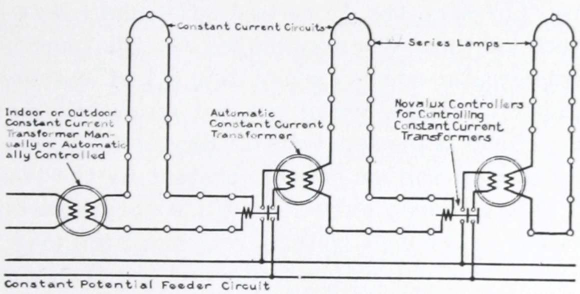


Diagram Illustrating Cascade Control of Series Lighting Circuits. Each Circuit Contains a Series Controller Which Controls the One Beyond

PILOT WIRE SYSTEM

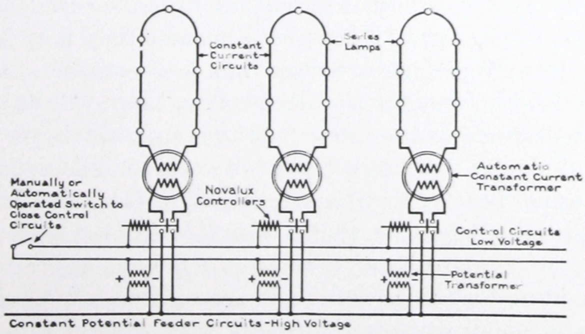


Diagram of Pilot Wire Control, Type RO Transformer. By Closing a Low-Voltage Pilot Circuit, Multiple Controllers are Operated Which Connect the Transformers to the Feeder Circuit

noted that one transmitter will actuate any number of receivers up to the capacity of the transmitter, also that there is one receiver for each transformer.

Schematic arrangement of pilot wire and cascade controls are shown in the accompanying diagrams. Time clocks may also be used with automatic transformers to close and open the circuit to the primaries of the transformers.

It is never the practice to open a live series circuit. If for any reason it is desirable to disconnect all or any part of such a circuit, that section is always short circuited before any work is done.

MULTIPLE SYSTEMS

Characteristics of Multiple Systems

The multiple system is the one with which the average layman is more familiar. It is the type of wiring that is prevalent in our homes, stores, factories, etc. In certain cities and towns it is used also for street lighting. When employed for this purpose, it has certain characteristics which are not found in the series system. Since a number of lamps are in parallel arrangement, the total current in the circuit is the sum total of the current passing through each lamp. The load voltage is held constant by the transformer, the no-load voltage (open circuit condition) being within a very small percentage of the load voltage. Any one lamp may be extinguished or may burn out without affecting the remainder of the system. Multiple street lamps may be on a circuit entirely separate from the other circuits, or may be tied in with the low voltage distribution network and operated either manually or through a pilot wire.

In the multiple system it is important to make sure that proper voltage is impressed upon all lamps—otherwise they may fall below rated life output. When a low voltage line is of considerable length, or when the load is large for the size of wire, there will be an excessive voltage drop along the line, and the lamps which are far from the source of supply will not receive full voltage. The usual correction is the use of heavier wire, shorter lines, or extra feeders. Under certain conditions it may be found desirable to provide a boosting transformer or regulator near the end of the line. Another method for compensating for this lowered voltage on a circuit would be the installation of small auto-transformers with several taps at each lamp location, the proper taps being used to supply the rated voltage to the lamp.

Characteristics of Lamps Used in Multiple Systems

When burned the filament of any lamp gradually vaporizes, and the tungsten vapor deposit on the surface of the bulb causes blackening. In multiple lamps this vaporization also causes the filament diameter to decrease—thus increasing the resistance and decreasing the current. The light output of a multiple lamp, then, decreases throughout life due to two related factors—bulb blackening and decreased light output of the filament due to decreased current. Data issued by the lamp manufacturers show the mean lumens in percentage of average initial lumens for different sizes of lamps. As an example, a 300-watt, PS-35 lamp has an initial output of 5280 lumens. The mean lumen output in percentage of average initial lumens is 90 per cent. Therefore, the mean lumen output throughout rated life is 4750 lumens and the final lumen output at the end of rated life is approximately 4250.

Multiple lamps are affected by variation in applied voltage. An increase in impressed voltage will increase the light output and decrease the life. Conversely, a decrease in voltage will decrease the light output and increase the life. For a further discussion of this subject see Bulletin LD-114C, *Theory and Characteristics of MAZDA Lamps.*

Characteristics of Distribution Systems and Their Effects on Lamp Performance

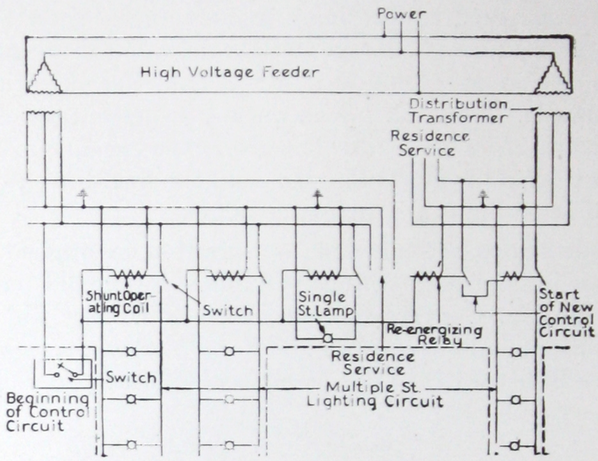
Central station practice is gradually developing toward the "network" idea. In the early days—and even in some sections today—there was what is known as a "radial feeder system." Under this scheme, a power transformer would serve a certain locality or group of houses, and would be isolated from all other transformers. Then, when anything went wrong, the whole locality was in darkness. Also, the further from a transformer a house was located, the lower would be the voltage and the lower the light output from the lamp.

Under the "network" idea, all transformers of an alternating current system, and the branch circuits of a direct-current system, are tied together in such a way that an ordinary failure does not materially affect the current supply to any locality. Furthermore, the voltage throughout the whole system is more uniform and has fewer and less violent fluctuations, thus assuring a proper voltage supply to the lamps.

Control of Multiple Street Lamps

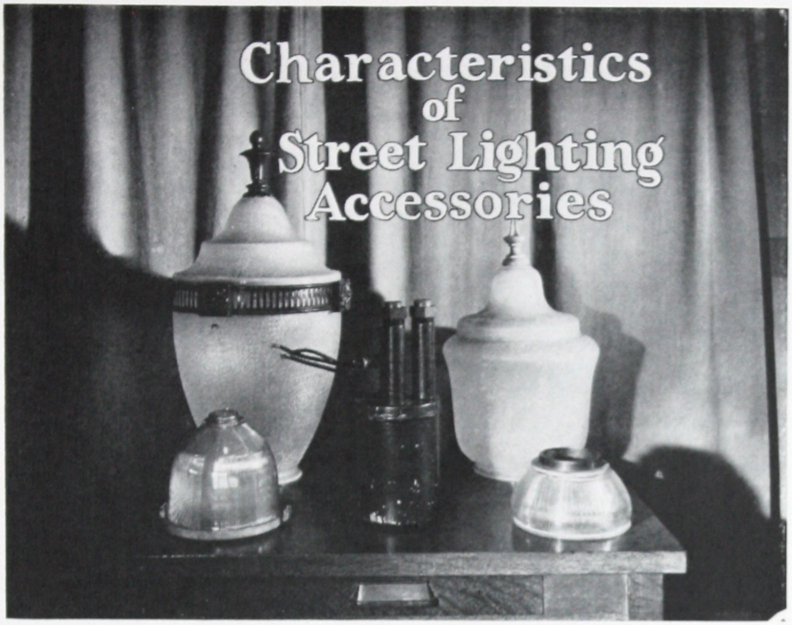
Multiple street lamps may be connected through a switch to the supply and turned on and off manually, this system having a low installation expense, but with relatively high labor charges.

Several lamps may be grouped as a branch circuit and actuated by a single switch or contactor. This device may be operated manually or remotely (through a pilot wire) or may be connected



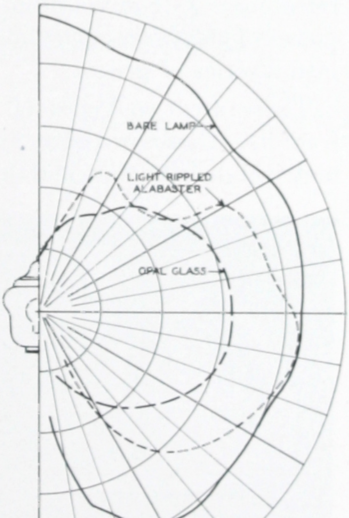
Schematic diagram of pilot wire control for a multiple street lighting circuit.

in a cascade system. With the cascade system, the application of voltage to one branch circuit operates a relay which switches on the next succeeding branch, and so on. Where contactors or control switches are used in pilot wire control, it is usually better to use "normally on"-contactors. This means that when the current is flowing through the pilot wire the control coil in the switch is actuated and the switch is open—the lamps being off. When the pilot current stops, the coil is de-energized, the switch closes, and the lamps are lighted. Continuous and uninterrupted operation is more likely to result from a "normally on" than from a "normally off" contactor. If desired, a time clock may be used to turn the branch circuit on and off.



Distribution of Bare Lamps

The distribution of light at various angles of elevation about a bare lamp depends upon the position of burning and the shape of the filament, as is evidenced from the accompanying curves. This distribution is modified by the equipment used with the lamps.

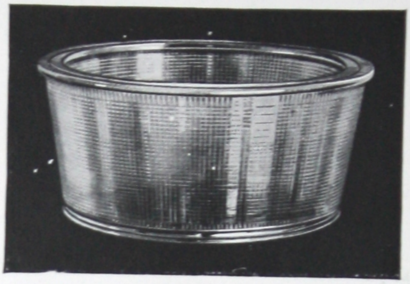


RELATIVE DISTRIBUTIONS WITH BARE LAMP AND ENCLOSING GLASSWARE

Distribution with Enclosing Glassware

While it is true that any type of globe surrounding a lamp will reduce the total light output of the unit, it is also true that proper equipment reduces glare, improves appearance and protects the lamp from the elements. For the above reasons, in a modern street lighting system the lamps are enclosed in glassware. This

outside glassware, in general, does not materially alter the distribution of light, as shown. Enclosing glassware may be either opal or rippled. The present tendency is decidedly toward the latter, for it presents a more pleasing appearance and gives a certain sparkle or animation to the light. The amount of light absorption depends upon the density of the glass, and will vary generally from 10 to 30 per cent.



Band Refractor—Symmetrical

Distribution with Refractors

It will be noted that part of the light from the bare lamp is directed above the horizontal. For some classes of street lighting this upward light is lost. A more economical utilization of the light results if this upward light is redirected toward the street surface. This effect may be obtained by the use of a refractor--a combination of pieces of glassware each molded into a series of prisms.

Bowl Refractor—Symmetrical

There are two types of refractors--those with a symmetrical distribution, and those with a non-symmetrical distribution.

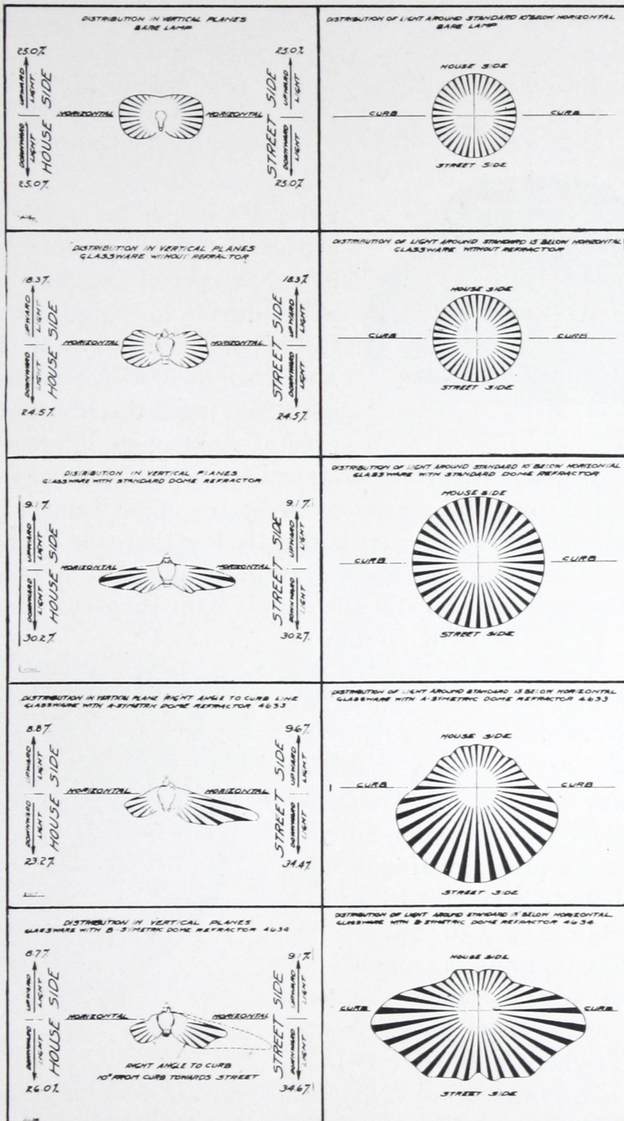
Dome Refractor—Symmetrical

Symmetrical refractors may be band, bowl, or dome shaped. The band and bowl refractors are used in pendent fixtures; the dome refractor in ornamental fixtures of either pendent or upright types.

Non-symmetrical refractors—in addition to redirecting downward the upward light—are so designed as to obtain maximum utilization of the redirected

RELATIVE DISTRIBUTION CURVES

DISTRIBUTION OF INTENSITY AND QUANTITY OF LIGHT FROM BARE LAMP AND VARIOUS REFRACTOR EQUIPMENTS
IN
G.E. 118 AND 1118 LIGHT ALABASTER RIPPLED GLASS WARE



PERCENTAGE FIGURES ARE BASED ON BARE LAMP LUMENS.

ALL CURVES TAKEN ON SAME SIZE OF LAMPS AND PLOTTED TO SAME SCALE.

light, by making sure that all possible light is effectively distributed over actual road surface, rather than the sidewalks, lawns, etc. These refractors may be classified as

1. Bowl
   (a) Two-way
   (b) Four-way
   (c) Highway (two-way)
2. Dome
   (a) A-Sym-Met-Ric *
   (b) B-Sym-Met-Ric *

* General Electric Company trade names.

Dome Refractor—Non-symmetrical

In some districts where pendent units are suspended over the center of the street, it is found convenient to use a special two-way refractor, which directs the light in two concentrated beams up and down the street. A companion four-way refractor, giving a four beam distribution, may be used at right angle intersections.

The highway refractor is designed for use on highway installations, and throws two concentrated beams up and down the road. The angle between the beams is slightly less than 180 degrees. This angle is provided so that the units can be mounted on poles at the side of the highway and still adequately light the road surface.

The A-Sym-Met-Ric dome refractor, when properly located near the curb line, redirects light so that nearly all of the emitted light falls upon the street surface, sufficient light, however, being transmitted in other directions to render adjacent buildings readliy distinguishable. The distribution of light toward the street is fan shaped so that the incident illumination is apportioned over the surface much the same as with the ordinary dome refractor.

Bowl Refractor—Non-symmetrical

The B-Sym-Met-Ric refractor also gives a non-symmetrical distribution, but, instead of giving a fan-shaped distribution like the A-Sym-Met-Ric dome refractor, increases the distribution up and down the street, and decreases slightly the distribution across the street. This refractor is designed for use on narrow streets, and where units are spaced relatively far apart.

The Relation of Lamp Size to Spacing and Mounting Height for Street Lighting

The three factors mentioned in the heading are very closely inter-related. One of the features which it is always necessary to combat in street lighting is glare. This discomfort is a sensation and is therefore subjective, being variable with the individual and difficult to measure. Glare is dependent on a number of conditions, as follows:

Brightness of light source.
Contrast between the source and the background.
Location in the field of view.
Total volume of light entering the eye.
Time of exposure.

Light sources of high brightness cause glare when viewed even casually. The glare from the sun or from an unshielded gas-filled incandescent lamp is sufficient to prove this statement. Objects of low brightness, not necessarily primary light sources, can also be glaring when viewed for a considerable length of time. For example, an overcast sky may be quite glaring.

If a decided contrast in brightness exists between the light source and its surroundings, the eye will be unable to accommodate itself to both extremes of brightness. This is particularly true in street lighting where there are generally the worst possible conditions to overcome—a dark sky overhead—a dark street surface, and, usually dark colored building surfaces. Is there any wonder, then, that there is contrast especially with low mounted light sources?

In a relatively dark room it is practically impossible for us to visualize objects if the lamps are level with our eyes. If, however, the lamps are elevated, we can discern things; the greater the elevation the better we can see. This same principle holds true in street lighting.

Tolerance of bright light sources is made possible by their being located at such height as to place them above the ordinary range of vision—the brighter or more powerful the light source, the higher it should be mounted, because in that way the total volume of light entering the eye is reduced. The following table gives, for various sizes of lamps, the minimum mounting height that is compatible with good street lighting practice.

Minimum Mounting Height

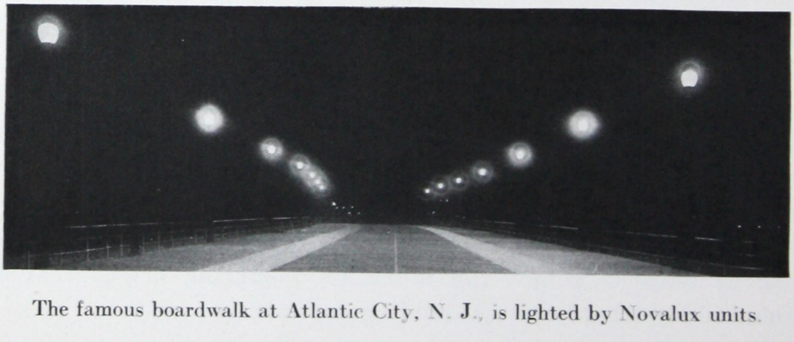
Lamp Size	*Distance from Ground to Light Source*
2,500 lumens	11 ft.
4,000 lumens	12 ft.
6,000 lumens	14 ft.
10,000 lumens	16 ft.
15,000 lumens	18 ft.
25,000 lumens	21 ft.

In many street lighting installations the variation in the illumination measured over the surface of the street and sidewalks exceeds a ratio of 100:1. Particularly for the pedestrian this is excessive, since it means that he must traverse spaces which are practically unilluminated. Where it is economically practicable to provide only the cheapest possible street or highway lighting, the vision of a motorist is usually better served by medium sized lamps producing spots of illumination on the surface, than by the more uniform lighting secured by smaller units—say 1000 lumens or less—at shorter spacings. But as the modern practice is tending toward more liberal use of light the trend is to secure a nearer approach to uniformity by the closer spacing instead of using more powerful lamps.

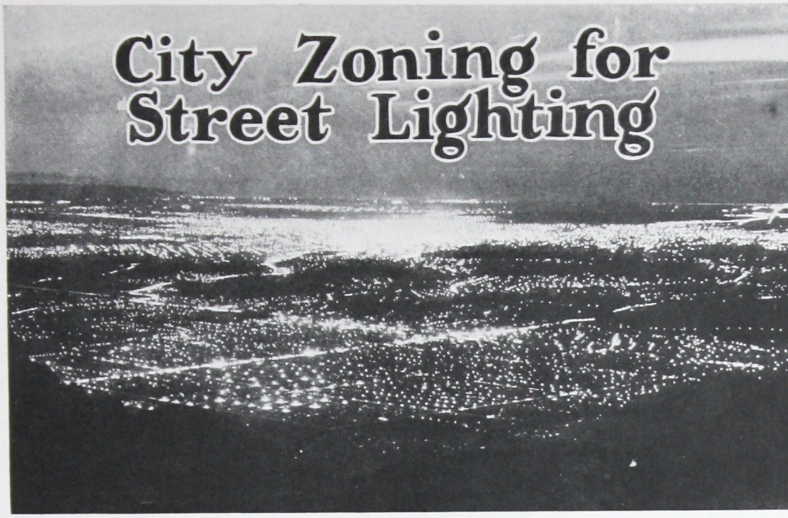
In high intensity street lighting—such as the so-called "white-way" installation, of which State Street, Chicago, is the most notable example, the uniformity is on the order of that obtained in indoor lighting.

It is the consensus of opinion among street lighting engineers that the spacing between lamps, for good practice, should not be greater than eight times the mounting height.

As a résumé, then, assuming a given mounting height, standards should be spaced closely together for uniform illumination; or, for a given spacing lamps may be mounted higher.



The famous boardwalk at Atlantic City, N. J., is lighted by Novalux units.



"City Zoning is the art of laying out cities to serve the business requirements, convenience, health and comfort of the public. It is guiding the growth of a village or city in conformity with a scientific design. It is adapting the physical form of a city to the peculiar needs of its parts." (*From a leaflet issued by the Minnesota Civic and Commerce Association.*)

Historical

The idea of laying out streets in a community along some well defined plan is not new. Even as far back as 2000 or 3000 years ago the Chinese realized the advantage and the utility of laying out a town or a village on a rectangular scheme. We find in the writings of Herodotus that Babylon was built four square with straight streets running parallel to the walls of the city. The workmen who built the pyramid of Illahun lived in villages "laid out symmetrically on rectangular lines."

Down through the various stages of Grecian and Roman civilization, we note the prevalence of rectangular plotting, especially in areas that were subjugated by the military authorities. It seems that it was second nature to soldiers to place people in some simple logical arrangement.

On the American continent, very few of the older cities were designed at their inception—they simply grew without any preordained plan. Their location was influenced either by natural surroundings—valleys, navigable streams, waterfalls and the like—or by railroads, crossroads, or some man-made improvement. From these simple beginnings it is easy to see that our forefathers devoted very little attention to such problems as civic development. Especially during the past decade there has been an increasing tendency to improve the city and to make it more livable. Officials are beginning to realize that cities cannot grow haphazardly—they must grow according to plans that will give the greatest good to the greatest number. Along with that thought is the idea that cities must plan for the future. It is not sufficient that we of the present generation enjoy life and the comforts of living—we must make sure that the generations to come will have the same advantages that we possess, and will have the foundation upon which to build future advantages.

Essentials of City Planning

City planning may be divided into various phases:

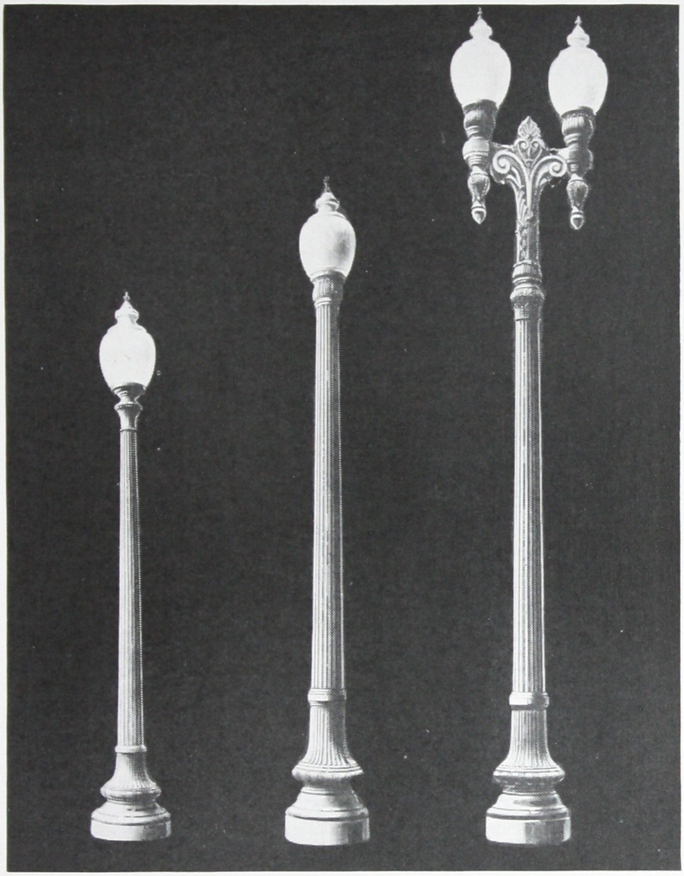
1. Re-planning of existing cities and towns—this may be classed as a remedial measure due to the lack of forethought in the past.
2. Planning of new cities.
3. Scientific platting of new sections of existing towns.

(These last two phases may be classed as preventive.)

The logical method of city planning is by means of zones—the dividing of the city into various sections, each of which contains buildings and industries of a certain character.

Charles M. Sasset, in his book entitled, "Assets of the Ideal City," has the following to say about zoning:

> Zoning sets aside certain areas for every reasonable use to which land and cities may be put; it arranges for facilities to accommodate specific uses, and prevents infringement or trespass of one use upon another. It determines the character of pavement and the height of buildings, it locates manufacturing plants and warehouses in districts easy of access by railroad sidings and heavily paved streets. It prevents the location of a stable, a garage or an undertaker in a purely residential neighborhood, and provides location for all sorts of business where it can thrive without damage to adjoining properties. It stabilizes realty values and gives greater permanence to investments in city properties. Zoning is the latest expression of the desire to make the city more livable for all of its inhabitants by reasonable application of a wholesome law.



In order to maintain uniformity in the lighting equipment in the various sections of the city, the practice has developed of using globes and poles of similar design, the larger sizes being used in the downtown business district while others, not as large, are used in the secondary business districts and residential sections.

Relation of Street Lighting to City Zoning

In any zoned city, the various public services are designed to meet the needs of the particular section, telephone facilities, electric light and power facilities—water, sewerage, etc. An electric light company or a telephone company knows by survey the present demand and load—where it is located, how it is growing and what its magnitude will probably be for the next decade or so. In exactly the same way the authorities responsible for street lighting should know the present requirements, traffic density, business and residential areas, and should by means of periodic surveys make plans for the future, estimating from the data obtained where the business districts are likely to expand, where they can expand, what the trend is in the residential movement, what effects interurban traffic will have, etc.

Knowing these facts it is possible to zone a city for its street lighting needs. In the larger cities there will probably be as many as seven classifications of streets as follows:

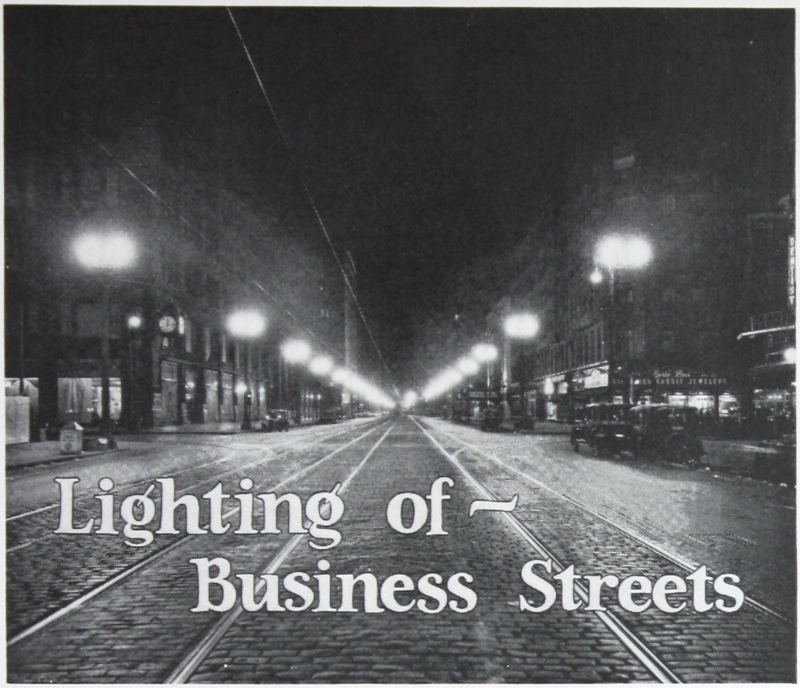
Principal business streets
Secondary business streets
Main thoroughfares
Residential streets
Parks
Boulevards
Highways

For smaller cities and towns some of the various classifications may drop out, until in the very small villages there are the two groups—business and residential streets.

A practice of maintaining similarity of design in globes and poles for all zones, seems to be gaining momentum among the larger cities. In the downtown sections large globes, tall poles, and large lamps would be in order. In residential sections globes of the same design, but smaller in size, with lower poles and smaller sized lamps would be used. These setups are commonly referred to as "Families of Standards." Several of these families are shown in the accompanying illustrations.

In the following sections we will discuss each classification separately under three headings:

General Requirements and Conditions of Surroundings.
Type of Unit and Method of Mounting.
Size and Spacing of Lamps.



LIGHTING OF PRINCIPAL BUSINESS STREETS

General Requirements and Conditions of Surroundings

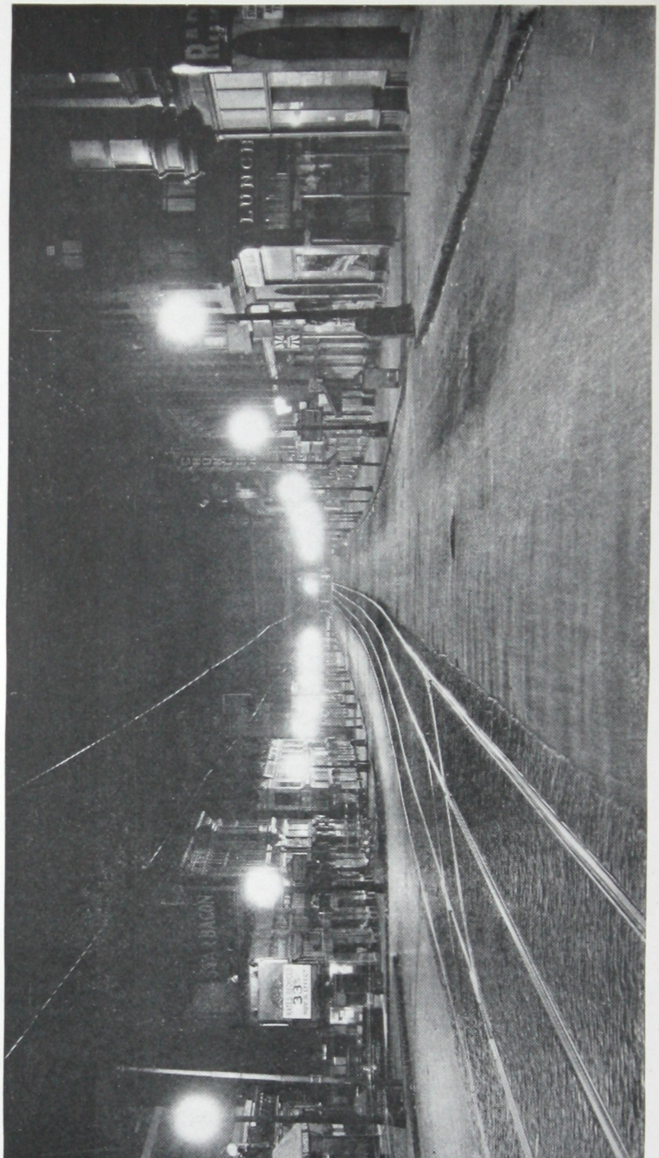
As the commercial life of the community is centered in its retail business district, the illumination here should be of the highest order, which has given rise to the so-called *WHITEWAY*. The installation should be such that it will provide:

1. A high level of illumination to attract the crowd, increase business, prevent accidents from the dense traffic, and decrease crime.

2. Quality with regard to color, diffusion of light, and freedom from glare.

3. A distribution so controlled as to give sufficient illumination to the street surface and at the same time allow enough light to strike the building front and make visible the architectural detail.

4. Units of such a character as to prevent an attractive appearance both by day and night, to harmonize with the character of the buildings, and to carry out the traditions of the community.



A well-designed lighting system, giving ample illumination, adds materially to the appearance of a retail business district. This view of Massachusetts Avenue, Boston, illustrates the result of careful planning. G-E Form 9 Novalux ornamental units with No. 107 globes and metal canopies are employed.

A distinctive characteristic of whiteway lighting is that more illumination is demanded between street intersections than on the corners themselves, whereas in all other classes of street lighting the maximum is required where the lines of traffic cross. The reason for this is that the publicity and decorative functions call for more light than would be required for reasonably safe travel.

Types of Units and Methods of Mounting

Whiteway lighting for the business section demands the use of ornamental types of fixtures or luminaires. These units are provided with diffusing glass globes of various designs surrounding the light source, to break up the light given off by the bare lamp. In this way, glare, which would otherwise be present is eliminated. The entire globe becomes the apparent source of light and, because of its comparatively low brightness, makes for greater eye comfort both for pedestrians and vehicular traffic. A distinct advance in the appearance of the street is obtained when this equipment is used. Such units ordinarily do not change the distribution of light given by the MAZDA lamp itself, as is indicated on page 21. Hence, this type of lighting, while allowing plenty of illumination on the street surface, sends light to the structures which are along the streets, causing them to stand out.

An excellent example of the more decorative type of lighting unit. This is a Form 12 Novalux with No. 124 alabaster rippled globe, No. 1124 alabaster rippled glass canopy, and Form "M" casing.

An attractive unit designed for bracket mounting. This is the G-E Form 32 Novalux suspension unit with No. 146 medium alabaster rippled globe.

Thus the street appears to be more luminous and pleasant than if the light were sent to the street surface only.

This diffusing glassware may be obtained in several varieties. Opalescent and rippled glassware are the most widely used. The opal glass affords a uniform brightness over the entire globe, while the rippled glass, by its slight refracting properties, gives a certain sparkle or animation to the illumination and at the same time permits more or less control of the distribution to meet particular conditions.

Single units, such as pictured, are recommended because of the higher efficiency which is obtained with one large lamp than with a group of small lamps. In the large cities, however, it is often desirable to install two or more such units on one standard to make an intensive or superwhiteway.

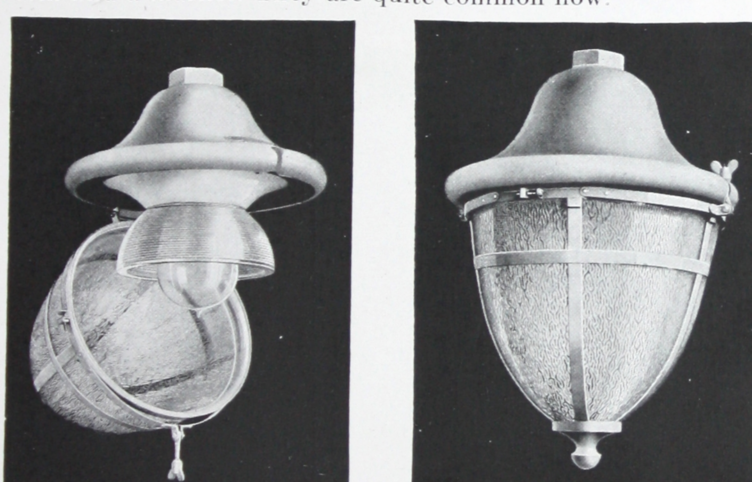
Perhaps the most attractive method of mounting the luminaires is to employ ornamental standards. These can be obtained in a number of beautiful designs, and are often so made as to incorporate some local tradition or history. The somewhat more economical method of using the trolley poles to support ornamental bracket fixtures, is, however, occasionally required by local conditions, and has the further advantage of avoiding a multiplicity of poles. The wiring, wherever it is economically practicable, should be underground, doing away with the overhead system.

Size and Spacing of Lamps

Considering any one section by itself—principal business, secondary business, etc., it is generally true that the larger the town the higher should be the illumination for any class of street. As an example, a city of 500,000 should have higher illumination standards on its main business street than should a city of 50,000. While it is true that the light requirements for safety may be the same in each case, it should be recognized that the advertising potentialities and the business potentialities are greater in larger cities; therefore, more light is needed to make these factors effective.

Boardwalk, Atlantic City, N. J.

There is really no upper limit to the amount of light that may be applied to a street, provided it is applied properly. Several years ago it was felt that 15,000 lumen and 25,000 lumen lamps would seldom find a market. They are quite common now.

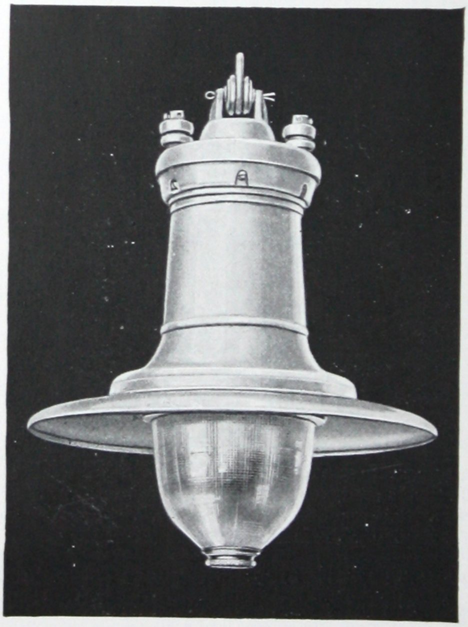


Two suspension units of pleasing appearance: at the left the Form 25A Novalux with No. 116 rippled globe, showing how ready access to the refractor and lamp is obtained by the hinged arrangement of the outer globe. The Form 25-B Novalux with No. 108 rippled globe is illustrated at the right.

High level street lighting for principal business streets is progressing. A partial list of several of the more intensive street lighting systems using Mazda lamps is as follows:

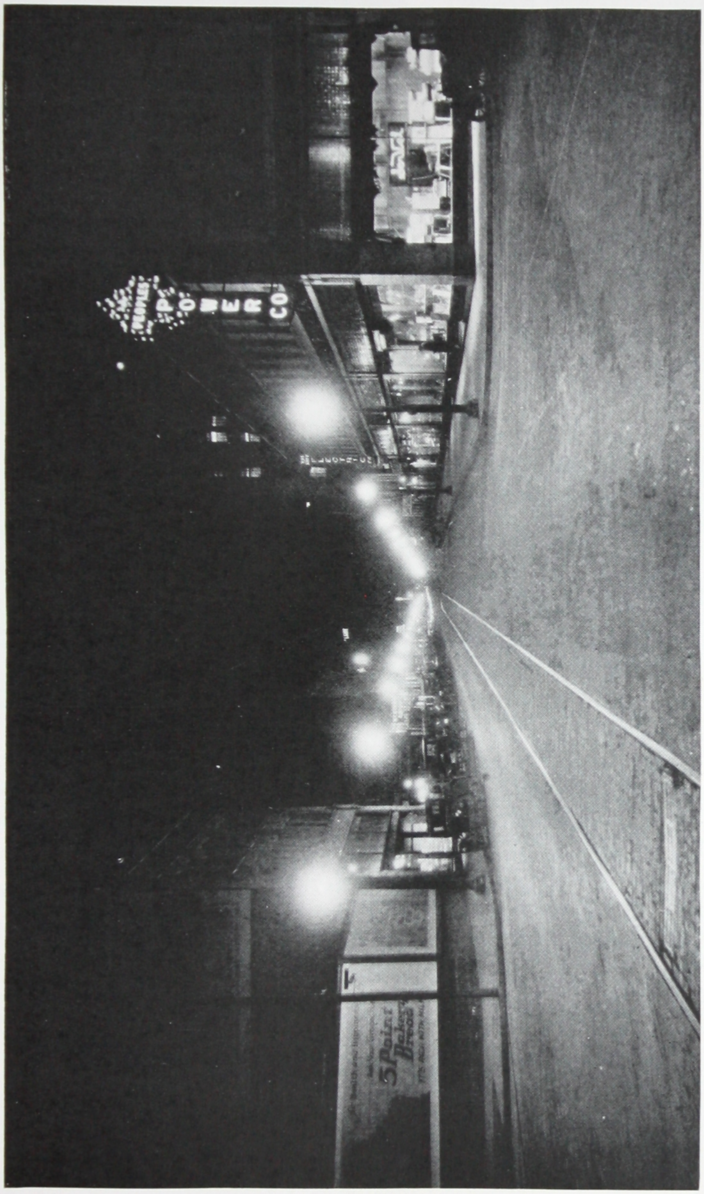
	*Lumens per Linear Foot of Street**
Chicago, Ill.—State Street	2000
Seattle, Wash.—Metropolitan Ave.	1050
Jersey City, N. J.—Journal Square Plaza	857
Portland, Ore.—Business District	600
Columbus, Ohio—Business District	600
Los Angeles, Calif.—Several Streets	375–510
Indianapolis, Ind.—Business Section	520
Cleveland, Ohio—Superior Avenue	500
Augusta, Ga.—Broad Street	450
Davenport, Iowa—Business Section	450
Newark, N. J.—Springfield Avenue	420
Boston, Mass.—Massachusetts Ave.	400
Lansing, Mich.—Business Section	400
Lawrence, Mass.—Essex Street	400
Chicago, Ill.—South State Street	400
Gary, Ind.—Business District	381
Racine, Wis.—Business District	350
Chattanooga, Tenn.—Business District	340
Cleveland, Ohio—Business District	333
Newark, N. J.—Broad Street	300

** As an index of grade of lighting, "Lumens per Linear Foot" is evidently inexact. No better basis of terse statement is, however, available for these installations.*



The actual spacing of units is governed by a number of considerations. The mounting height (see "Lamp Size, Spacing and Mounting Height"), uniformity of distribution, width of street, length of block, location of trolley poles, etc., all bear on the subject.

For the illumination of secondary business streets and other thoroughfares where overhead wiring is necessary on account of economic factors, the Form 6 Novalux with bowl refractor is often used.



One is impressed immediately by the attractive appearance of this downtown business district of a city of the 25,000-100,000 classification shown on page 37. This photograph shows Fifth Avenue, Moline, Ill., where G-E Form 9 ornamental Novalux units with No. 118 medium alabaster globes are used for lighting equipment.

For a fair uniformity of distribution, it is well to keep the ratio of spacing and mounting height approximately eight for streets for normal width (up to 60 ft. from curb to curb). For wider streets the ratio will decrease—in order that uniformity may be maintained.

In lighting streets of ordinary width, it is the common practice to utilize a row of lighting units on each side of the street. This arrangement gives a proper distribution of light and a desirable uniformity of appearance. The units are mounted either opposite or staggered, the staggered system not being as satisfactory as the opposite system for very wide streets. The staggered system gives very good results on streets less than 40 ft. wide. The appearance of uniformity is in this way maintained and a much more effective distribution of light is obtained. The length of the blocks or the location of trolley poles quite frequently set arbitrary limits for spacing.

Typical ornamental unit used in business district lighting.

It is also important to note, that for a given spacing the cost of street lighting does not usually increase nearly so fast as the size of the unit. Not only are the larger lamps more efficient, but the overhead cost almost invariably becomes a relatively smaller factor for the larger lamps.

Lighting Essentials for Principal Business Streets

	SIZE OF CITY			
	500,000–up	100,000–500,000	25,000–100,000	5,000–25,000
Lumens per foot	700–up	200–1000	80–300	60–150
Number of lamps per pole......	2 or 3	1, 2 or 3	1 or 2	1
Total lumens per pole.........	30,000–up	10,000–50,000	6,000–15,000	6,000–10,000
Mounting height	22–30 ft.	18–25 ft.	14–20 ft.	14–16 ft.
Spacing........	90–130 ft.	90–130 ft.	90–120 ft.	80–100 ft.
Arrangement....	Opposite	Opposite	Opposite	Opposite or staggered

LIGHTING OF SECONDARY BUSINESS STREETS

General Requirements and Conditions of Surroundings

This classification includes the less important business streets adjacent to the main business street, and those smaller business centers which spring up in semi-suburban districts of all cities.

On these streets it is obvious that the level of illumination will be somewhat lower than on the principal business section. It should, however, be of a comparatively high standard.

There is not the same demand for the publicity element, neither is the traffic likely to be so dense on this class of street, therefore a slight decrease in illumination is possible without increasing the number of accidents. There will still be provided ample illumination for the prevention of crime.

In a business district where it is desirable to use units of ornamental design, the Form 9 Novalux, with No. 107 alabaster rippled globe and No. 1107 rippled canopy, is often employed.

The buildings lining the secondary business street are not so high as along the main business section, neither are the streets usually as wide.

The requirements, then, are:

1. A moderately high level of illumination to increase business, and to prevent accidents and crime.
2. Quality with regard to color, diffusion of light, and freedom from glare.
3. A distribution so controlled as to give sufficient illumination on the street surface and, at the same time, allow enough light to strike the building fronts and make visible the architectural details.
4. Units of such a character as to present an attractive appearance, both by day and night, to harmonize with the character of the building, and to carry out the traditions of the community.

Type of Units and Methods of Mounting

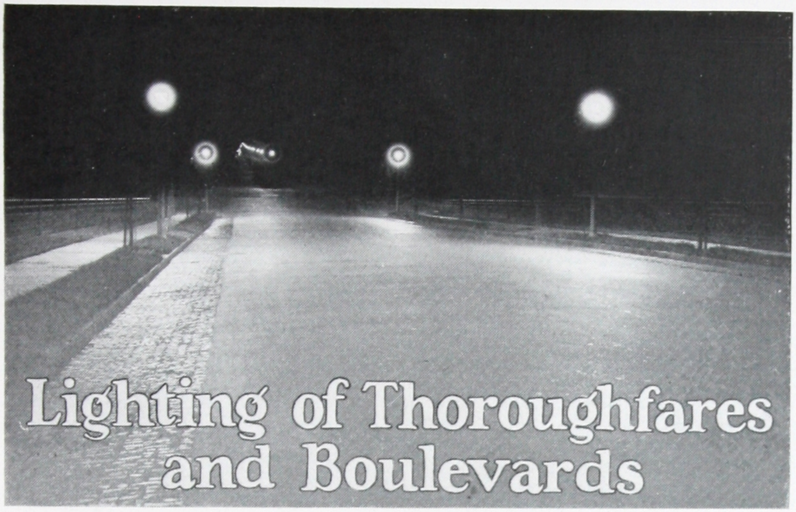
In general, the ornamental system of the principal district should be continued to preserve the uniformity of appearance. It is, however, sometimes necessary to use a somewhat wider spacing, smaller lamps, or more economical equipment, even at a sacrifice in appearance. In this case a pendent or bracket type of unit with diffusing globes, would be recommended.

Refracting equipment is generally desirable with either type of luminaire, especially if the spacing is fairly wide.

Because of development of refracting equipment, the distribution of light from street lighting luminaires can be quite accurately controlled to give the maximum candlepower at any desired angle. This is ordinarily 10 to 15 degrees below the horizontal. The directional effect is obtained by means of a prismatic glass refractor, the prisms being so designed that they refract or bend the light into desired directions. Refractors may be used with the ornamental glassware, or, together with socket, housing, etc., may complete the unit.

Size and Spacing of Lamps

In general, definite secondary business districts as such will not exist in towns smaller than 50,000. For data on the recommended values, reference is made to the above table under the next smaller group size. As an example, the secondary business district of a town falling within the 100,000–500,000 group would be adequately illuminated by using the figures for the primary business district of the 25,000–100,000 group.



General Requirements and Conditions of Surroundings

Thoroughfares, comprising the main routes through a city, may be streets that would otherwise be classed under one of the other headings. They are subjected to a heavy flow of high speed traffic. In the business district traffic is usually so dense that speeds of travel are necessarily slow. In the thoroughfares, however, with a wider effective street (because of the absence of the parking evil), more cars can be accommodated; they are usually not of the "short haul" variety, and speeds are considerably higher. To provide safe conditions on these streets requires a high level of illumination. Enough light should be provided to eliminate the necessity of bright headlights on the cars. The driver can then readily discern objects in his path, and is able to act quickly, thereby reducing accidents to a minimum. Traffic is handled much more readily and speedily under the higher illumination, thus increasing the capacity of the road.

Where there are practically no building fronts which require illumination, the upward light may well be redirected toward the street surface. For this purpose a refractor may be used within the equipment, obtaining by this means a more efficient utilization of the light without sacrifice to any other surface.

The illumination requirements for these classes of streets, then would be as follows:

1. High level of illumination to provide for safe movement of speedy traffic.

2. Quality with regard to diffusion of light and freedom from glare.
3. A controlled distribution directing the preponderance of light to the road surface.
4. Units of such a character as to present an attractive appearance by day and night, at the same time harmonizing with the surroundings.

Some residential streets carry quite heavy through traffic. They really should be classed as thoroughfares and lighted as such.

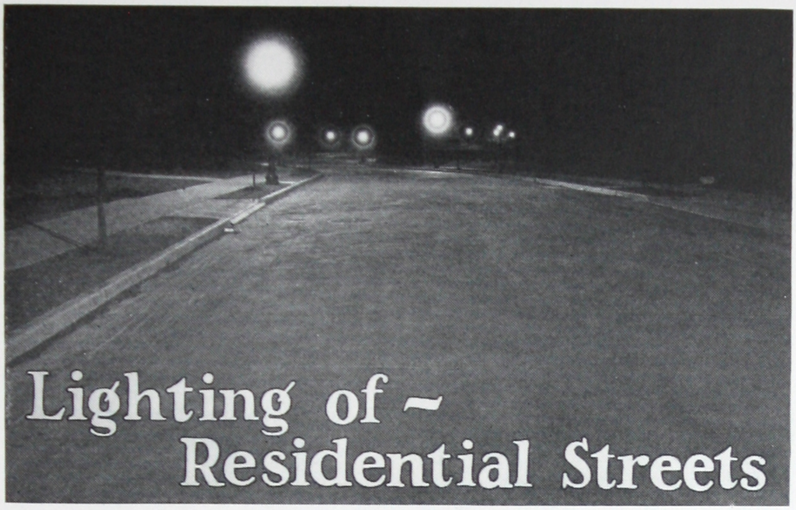
Types of Units and Methods of Mounting

Ornamental units on ornamental poles may be used on these streets continuing the "Family of Units" idea. Quite frequently the use of a bracket fixture has created effective lighting. This latter method of lighting has several advantages. By putting the lamps out over the street surface the utilization of the light is increased, foliage interference is reduced, better silhouette vision is provided, and the curbs are more distinctly illuminated.

In the business streets where there are lighted signs, lighted show windows, and relatively close buildings, a definite mounting height for the street lighting fixtures may present a permissible degree of contrast. The same fixture on thoroughfares and boulevards, however, would in all probability be glaring because of the absence of lighted backgrounds. It is therefore desirable to secure a somewhat higher mounting height for this class of service.

Lighting Essentials

	Cities Above 100,000	*Cities Below 100,000*
Lumens per foot	50–150	40–90
Number of lamps per post	1	1
Lamp size	6,000–15,000 lumens	4,000–10,000 lumens
Mounting height—upright	15–20 ft.	14–18 ft.
Mounting height—bracket	20–25 ft.	20–22 ft.
Spacing	100–125 ft.	100–125 ft.
Arrangement	Staggered	Staggered



General Requirements and Conditions of Surroundings

Disregarding those used as thoroughfares, residential streets are generally subject to a relatively small amount of vehicular traffic. Nevertheless they should be adequately illuminated, so that pedestrians and householders may have a feeling of security.

There should be no dark pockets on the streets, lawns, or between houses. One should be able to recognize road obstructions, transverse and parallel traffic, turns, dead ends, steep grades, railroad tracks, etc. Considerable care must be taken in residential street lighting to avoid objectionable light on the houses. A great deal of complaint has arisen in this way, involving considerable expense in changing units from one position to another. This may be alleviated in practically all cases, however, if the light is so directed as to allow little or no illumination to strike higher than the first story.

Usually a residential street has a row of trees along each side, making it a hard problem to get illumination as uniformly as desired upon the street surface, because of the dense foliage. It is a common practice to mount rather large lighting units, like that shown on the next page, at each street intersection, light from these units being sent in each direction down the intersecting streets. This gives the most light at the street corners where there would be more likelihood of traffic accidents. Intermediate lamps are needed however, to light properly any but the shortest blocks, in order to avoid objectionable dark areas. Even when refractors are used to widen the

distribution, at least one additional lamp should be used in a block of average length. Units should be placed regularly along the street and so mounted as to eliminate interference by foliage. On the older residential streets, the trees are for the most part of considerable size, usually trimmed quite high, allowing lighting units to be placed below the branches. Thus, but little illumination is lost in the foliage. On the newer streets, the trees are apt to be quite young, with branches starting 7 or 8 feet from the ground. Here much

Although an efficient unit is used here, equipment of a more ornamental design would be in better harmony with the high character of this residential thoroughfare.

trouble occurs because of the units coming among the branches, resulting in a serious obstruction of the light by the foliage. To avoid this, the lamps may be mounted on brackets, of the type shown on page 44, extending over the roadway to clear the branches.

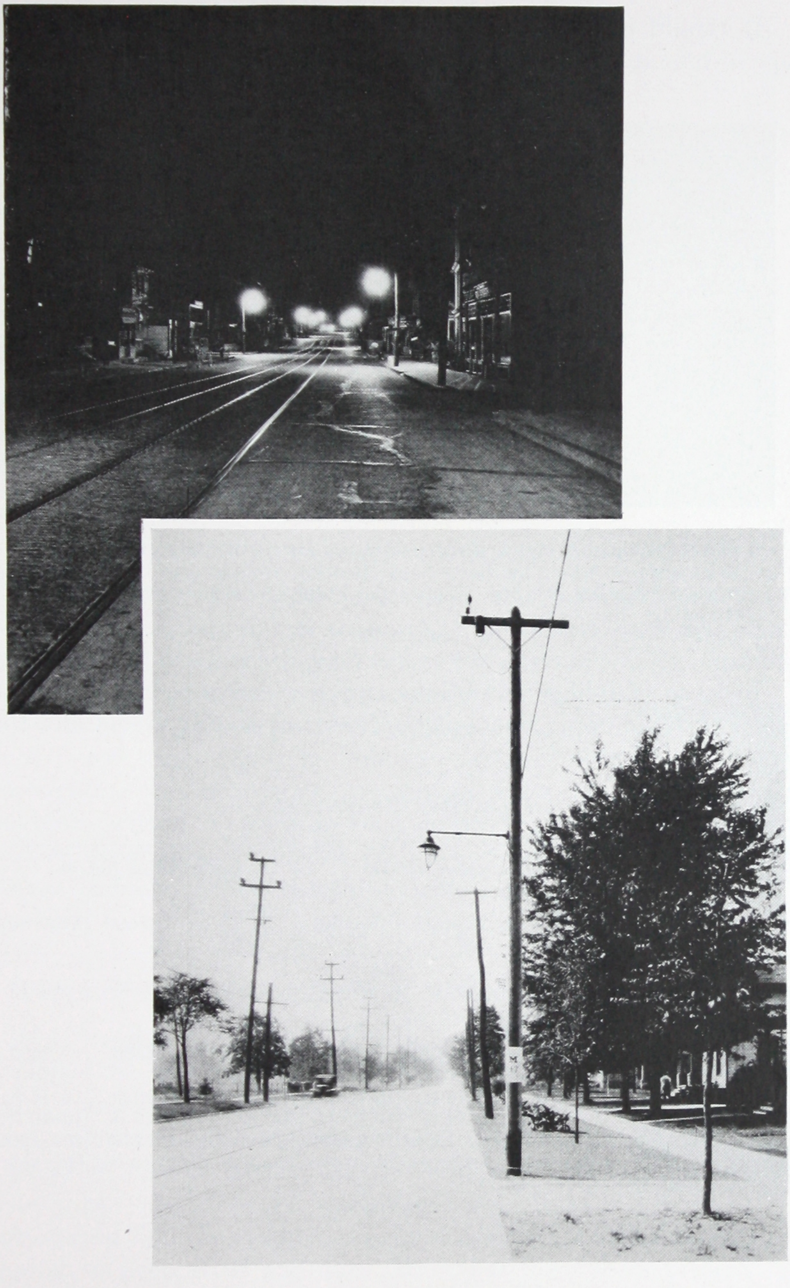
Most cities have realized the extravagance of allowing the forestation along the streets to reach such a magnitude that it seriously affects the illumination of their streets, and have therefore passed ordinances compelling residents along the streets to trim their trees up to a certain height. Other cities have gone a step farther and have hired competent men to take care of this work under the supervision of the Park Departments.

Types of Units and Methods of Mounting

The "Family of Standards" idea may be continued to residential streets—employing ornamental units and ornamental globes.

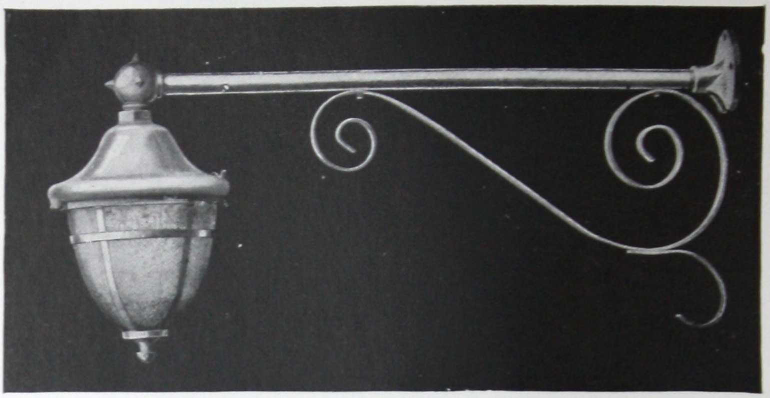
Pendent fixtures attached to bracket arms may also be used. In fact, the advantages mentioned regarding this type of unit in "Thoroughfares and Boulevards" hold true here. These points briefly are:

- Increase in the utilization of light
- Reduction of foliage interference
- Provision for better silhouette vision
- More distinct illumination of the curb.



Adequate lighting does not necessarily imply that ornate equipment must be used. In these two installations very good results are obtained with units of simple and pleasing design.

It should be borne in mind that these fixtures may, by their type of mounting, be just as ornamental as an upright fixture.

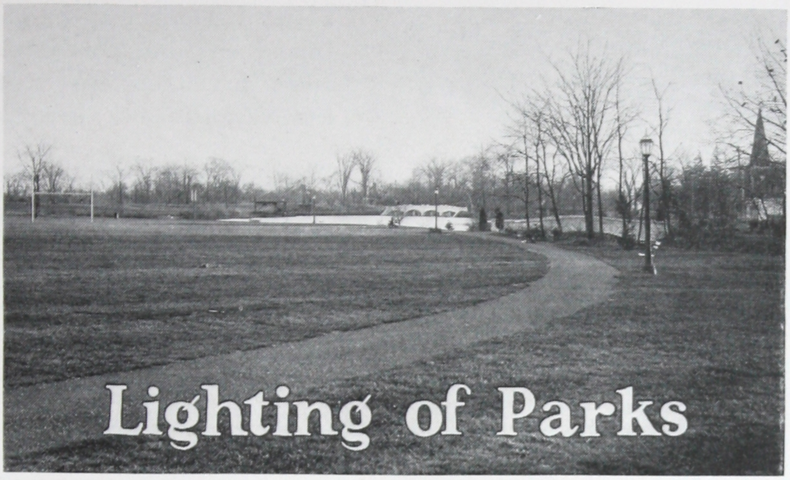


A form of equipment that is finding wide use for the lighting of residential thoroughfares, where the units must often be extended over the roadway to clear branches of trees. This is the Form 25 Novalux with a bracket mounting.

Because of foliage conditions and the desire to minimize the lighting on the upper floors of residences, it is well to consider the use of refractors.

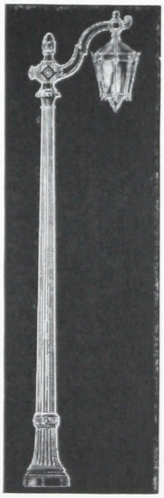
Lighting Essentials

	Cities Above 100,000			*Cities Below 100,000*		
	High Class	Normal	Sparse	High Class	Normal	Sparse
Lumens per foot	30–60	20–40	10–20	25–35	10–20	10–15
Number of lamps per post	1	1	1	1	1	1
Lamp size	4000–6000	2500–4000	2500	4000	2500	2500
Mounting height—						
Upright	13–16 ft.	13–16 ft.	13–16 ft.	13–16 ft.	13–16 ft.	13–16 ft.
Bracket	16–20 ft.	16–20 ft.	16–20 ft.	16–20 ft.	16–20 ft.	16–20 ft.
Spacing	100–130ft.	120–150ft.	150–250ft.	120–150ft.	150–250ft.	200–250ft.
Arrangement	Staggered	Staggered	Staggered or one side	Staggered	Staggered	One side



General Requirements and Conditions of Surroundings

Park lighting is a phase of outdoor illumination which is of considerable magnitude and a necessary element in park planning. The walks and roadways in parks do not need so much illumination as a street proper, except in the cases of heavily travelled thoroughfares within the park area, in which case the lighting should partake of thoroughfare characteristics. A certain sense of duskiness within a park is very desirable on a summer evening and can well be allowed, insofar as may be found to be compatible with maintaining order.



Types of Unit and Methods of Mounting

It is evident that, in a park which is to be developed to the highest artistic standards, the appurtenances of the park should be designed for beauty of individual detail. In the development of parks in foreign cities even the receptacles for waste paper are designed conscientiously. Even more should lighting standards exhibit intelligent design, and be pleasing in proportion and lines. Much has been accomplished in park lighting in the last three years, but there is still much room for improvement. Good practice in park lighting demands ornamental

fixtures. These may be obtained in different forms which harmonize well with the various park designs.

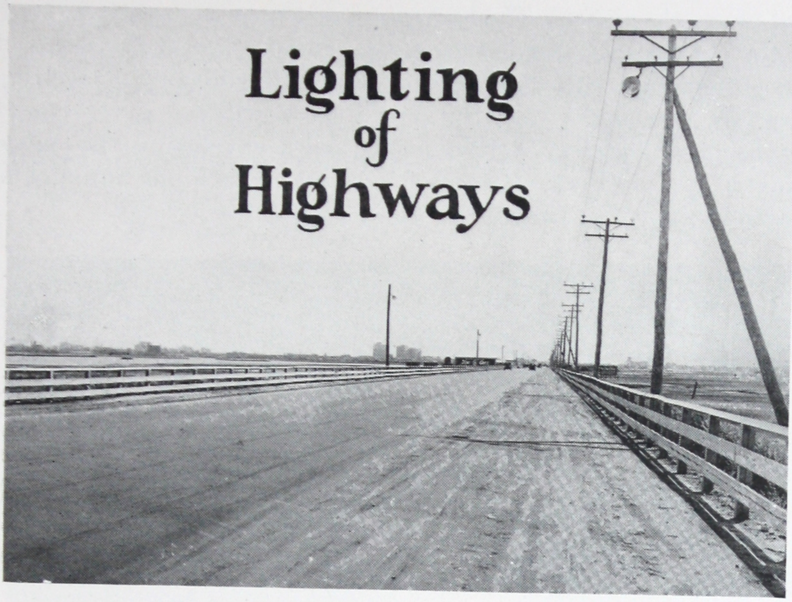
Where utilitarian equipment is not required, as in parks, a distinctly pleasing effect is obtained through the use of poles simulating limbs of trees, giving a rustic appearance in keeping with the surroundings.

Some very effective designs of lighting units are shown in the accompanying illustration.

The placing of the lighting standards should be determined with regard to even distribution of light and at the same time with reference to the lines of the park design. It is obvious that lighting standards should not be so placed as to interfere, during the day, with vista and thus become a distracting element in the park design. In formal parks, in fact, they may be made to serve as a very helpful accent to the design, and should be used for this purpose by the park designers much as ornamental fixtures are used by architects in the composition of buildings. Ornamental standards may be obtained in various designs to conform to the different classes of landscape architecture. There is little or no demand for the illumination of building fronts, and practically all upward light is wasted, except for giving artistic effects of glassware. It would seem, then, that refracting types of units may be found quite desirable in this section of the city.

Lighting Essentials

Number of lamps per post	1
Lamp size	2500–4000 lumens
Mounting height	Upright 13–15 ft.
Mounting height	Bracket 16–18 ft.
Spacing	100–200 ft.
Arrangement	Staggered or one side



General Requirements and Conditions of Surroundings

The ever-increasing amount of traffic on our main highways has so congested them that the need of some means of relief has become acute. The number of cars on some of our metropolitan highways has swelled to such a volume that there is a continual procession of automobiles, especially during the evening hours, and while the number of vehicles upon the highways has increased tremendously, the capacity of the highways has remained practically constant. As a direct result of this congested condition, there has been a considerable increase in the number of serious accidents happening upon our main highways. Precautions have been taken to protect the traveling public by posting all sharp curves, narrow bridges, steep grades, and the like. The protection afforded by this means does not, however, extend adequately beyond the hours of daylight when the automobile drivers have to depend entirely upon headlights. While recent improvements in headlights through the enforced use of proper lenses and size of lamp have greatly improved night driving from the safety standpoint, there is still considerable objectionable glare present.

The automobile headlight is not an adequate solution to the problem. We cannot expect to illuminate the highways properly and without glare, using rapidly moving light sources only three

feet above the ground. The highways must be permanently lighted, as the streets are being permanently lighted, to meet the needs of the automobile age. No man of vision, familiar with lighting progress, can doubt that the next decade will see a very great extension of highway lighting, eventually enveloping the entire country in a network of lanes of light over which our automobile traffic will move as swiftly and safely by night as by day.

It has been conclusively proved that highway accidents at night are very materially reduced by adequate illumination, and improved lighting conditions keep pace with the popular demand for better roads. This highway, Hylan Boulevard, Long Island, N. Y., is an excellent example of modern practice in this phase of the lighting art.

The cause of a large percentage of night fatalities has been the inability of vehicle drivers to perceive pedestrians on the highway at a great enough distance to avoid collision.

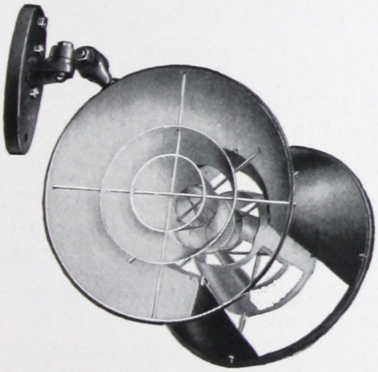
The increasing number of trucks operated on all-night schedule has added another danger to night traffic. They move comparatively

slowly and are generally equipped with less efficient headlights than are passenger cars. This means a general slowing up of the entire traffic along the highway as well as seriously augmenting the possibility of collision. Because of the inadequate illumination afforded by headlights the driver is also likely to strike obstructions or holes and do considerable damage to both the truck and the highway. Quite often, the driver, not being able to discern the outline of the road clearly, runs off the road bed on to the side of the road which, being of poorer construction, cannot stand the dead weight thrust upon it.

Night traffic is also increased by the large number of passenger buses operating between cities. These are of considerable size and come under the truck classification, although they are essentially of passenger car speed. The seriousness of a collision or accident to a vehicle of this nature would be great, and every possible means should be taken for the protection of the traveling public.

Another danger of night driving is present in the form of hold-ups or robberies. During the last three or four years there has been a great deal of activity along these lines, until in certain sections of the country no one dares stop to render assistance when requested, for fear of being waylaid.

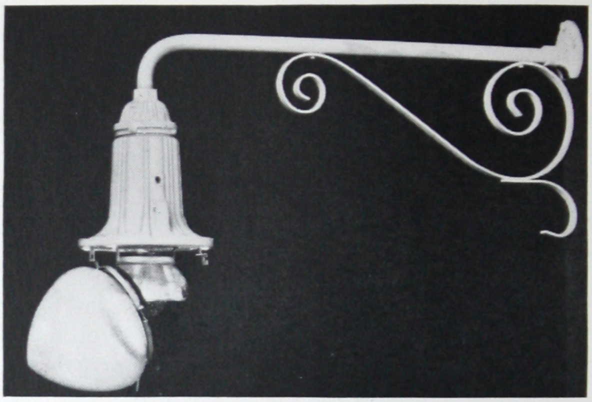
The severe requirements for highway lighting make it a very difficult problem to solve. One of the most important considerations is cost. It is entirely obvious that as few units as possible should be used, and, at the same time, illumination should be sufficient for safety. There should be such illumination upon the roadway as to enable the driver to see pedestrians or obstacles in his path at a safe distance, and the outlines of the road at all times. Enough light should be provided as to eliminate, as far as possible, the glare from approaching cars. Dangerous curves, steep grades and narrow bridges should be properly protected, by being made visible at night.



Novalux highway lighting unit showing nested parabolic reflectors by means of which a directional lighting effect is obtained

Types of Unit and Method of Mounting

Probably the first real scientific attempt to solve the highway lighting problem was the development of the General Electric Nested Parabolic Unit, which has proved to be a truly remarkable lighting unit. It is normally mounted 30 to 35 feet from the ground, uses a 2500- or 4000-lumen MAZDA C lamp, and is spaced every 300–500 feet depending upon the density of traffic upon the highway.

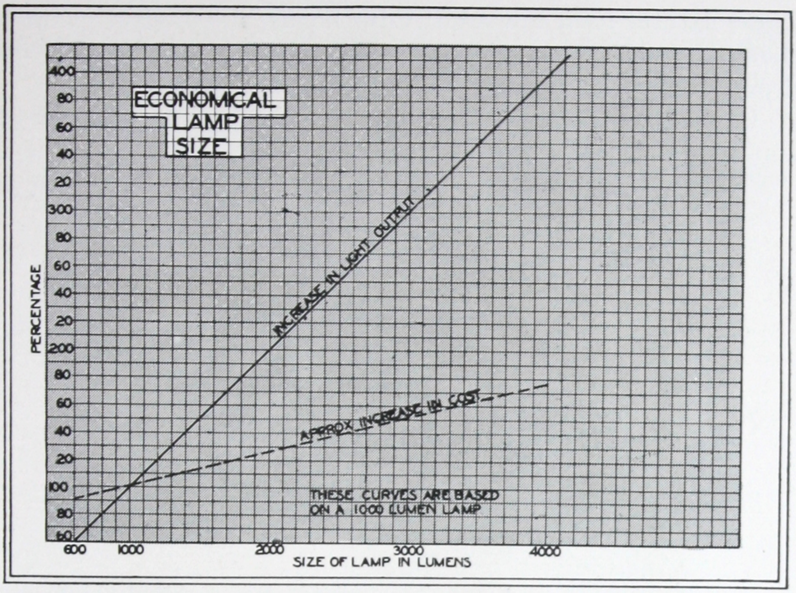


A form of unit that is extensively used for highway lighting. This is the Novalux Universalite with No. 120 rippled globe. By means of a B-Sym-Met-Ric dome refractor the larger portion of the light is directed up and down the thoroughfare. This refractor is designed for use where the roadway is narrow and the units are relatively far apart.

Under present conditions, many public utilities run some of their high voltage lines on the same poles that carry a highway lighting circuit. With this set-up, it would be decidedly unwise to attempt a mounting height of greater than 20 to 25 feet for highway lighting fixtures. Where such is the case a pendent fixture attached to a bracket—using a 2500-lumen lamp, of a type such as illustrated, may be employed. This unit consists of a combination reflector insulator, and lamp socket housing—and is equipped with a B-Sym-Met-Ric refractor.

LIGHTING ESSENTIALS

	Nested Parabolic Reflector		Pendent Fixture with B-Sym-Met-Ric Refractor	
	Main Traveled Highways	Less Important Highways	Main Traveled Highways	Less Important Highways
Lamp size	2500–4000 lumens	2500 lumens	2500–4000 lumens	2500 lumens
Mounting height	30–35 ft.	30–35 ft.	20–25 ft.	20–25 ft.
Spacing	300 ft.	350–500 ft.	250–300 ft.	350–500 ft.
Arrangement	One side	One side	One side	One side



An electric service company charges a certain rate per year for a street lighting fixture, depending upon the type of fixture, the lamp size, etc. This sum includes all charges against the fixture, and for our purposes may be divided as follows:

1. Cost of energy
2. Cost of lamp renewals
3. Maintenance
4. Fixed charges.

During the period of a year, a lamp will consume a certain number of kilowatt-hours. The cost of this energy, then, must be charged in the rate.

Inasmuch as incandescent lamps have only a limited life, it is necessary that new lamps be installed when others burn out. The cost of these renewals forms the second item.

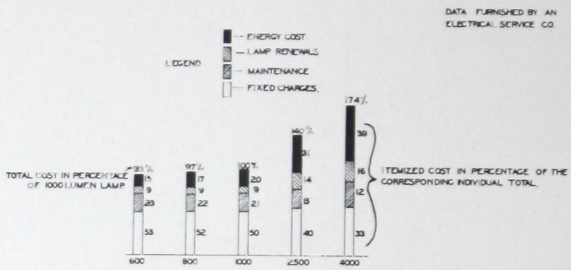
Fixtures must be cleaned in order that the light absorption be minimized and also that the units present a favorable appearance. Patrolmen must be on the watch for burned out lamps and for circuit outages. Repairs must be made to the lines occasionally. These current charges are all grouped under maintenance, and form the third item.

There is a certain amount of money invested in the lighting system—transformers, cable, fixtures, allocated pole cost, etc.

These fixtures form the security for bonds, the interest on which should be charged to the street lighting system. Obsolescence, depreciation, and amortization also must be accounted for.

Of these four items, the first two are the only ones that increase appreciably as larger size lamps are used.

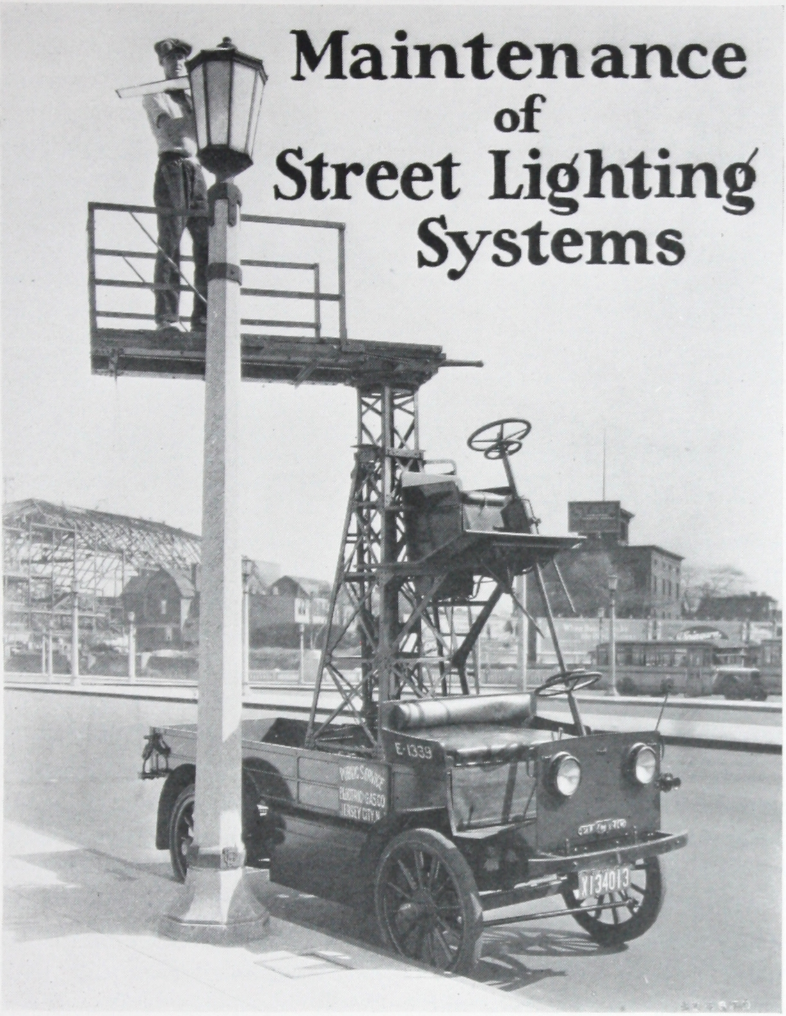
RELATIVE COST OF FIXED AND VARIABLE CHARGES FOR STREET SERIES LAMPS ASSUMING THE SAME TYPE FIXTURE THROUGHOUT



With increased candlepower, a lamp will naturally consume more energy, and, being a larger lamp, will cost more. But since the larger lamps are more efficient and do not cost proportionately, even this item is relatively low for larger sizes. Maintenance and fixed charge items will increase at only a very slight rate—as indicated. It can be appreciated, therefore, that lamps of 1000 lumens and below are uneconomical propositions, inasmuch as such a large proportion of the total cost may be said to be a non-productive overhead item. Thus in a representative case the maintenance and fixed charges on a 600 lumen (60 candlepower) lamp represent 76 per cent of the total cost (leaving only 24 per cent for productive purposes), while in the 4000-lumen size (400 candlepower), 45 per cent is overhead while 55 per cent is productive.

Because of the above facts, and the higher efficiency of larger size lamps, it will be noted that the increase in light through the use of larger lamps, is much higher than the relative increase in cost. Assuming that a 1000-lumen lamp costs 100 per cent, it will be noted that a 2400-lumen lamp costs 140 per cent. In other words, for a 40 per cent increase in cost one may obtain a 150 per cent increase in illumination. With the 4000-lumen lamp, the figures are even more striking—a 300 per cent increase in illumination can be secured for a 74 per cent increase in cost.

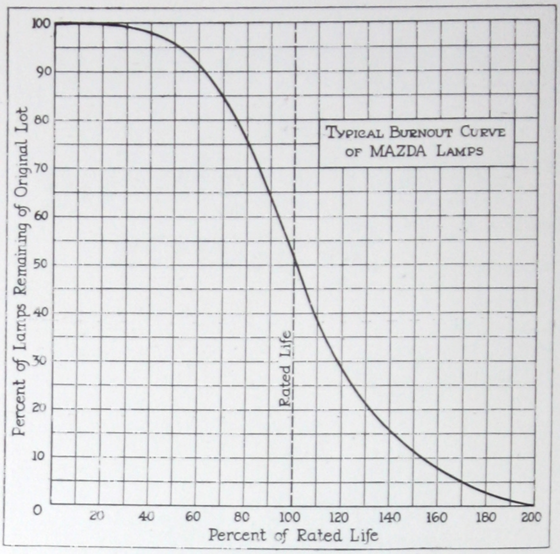
Furthermore, this increase in lighting on our streets is necessary and justified.



Fixture Maintenance

Particularly in street lighting, once the fixtures are installed, they must be serviced and maintained. The accumulation of dust and dirt on fixtures, in addition to creating an unfavorable impression, reduces the light output as much as 40 per cent in extreme cases. This lost light cannot well be afforded, particularly when so many of the streets are under-illuminated.

Periodic systems of cleaning and maintenance are in force among many of the progressive central stations. The fixtures are



thoroughly cleaned with an active cleanser from four to twelve times a year, depending upon the prevailing conditions of the particular area.

It should not be expected that a lighting fixture exposed to all of the elements and surrounding conditions, as smoke, dust, and dirt, as is a street lighting unit, will maintain its light output and present a favorable appearance unless it is given an opportunity to do so.

Lamp Maintenance

Conditions differ as to the method of replacing burned out or blackened street lamps. With practically all operating companies, the governing feature is that outages must be replaced within a definite period from the time the lamps are reported "out"—otherwise a penalty is incurred.

In meeting this condition, some companies replace lamps only when outages are reported. Other companies maintain patrol services replacing burned out or badly blackened lamps on their own initiative. Still other companies maintain card indexes of the lamps and replace those which have burned a definite number of hours, feeling that the lamps have lived their useful life. Another method in operation is to divide the territory into districts, replacing all lamps when the outage rate becomes high.

From the standpoint of actual economy of operation and maintenance, it would seem that where the labor cost of replacing lamps individually is high, there would be a point of balance where a saving can be effected by replacing groups of lamps even previous to the expiration of their rated life.

Other uses of ~ Street Lighting Circuits

While street lighting is essentially a municipal function carried on through the agency of the electric service company, it so happens that there are other uses besides street lighting to which these circuits may be put, without endangering in any way the relation between the two above-mentioned bodies—at the same time creating additional revenue for the electric service company and allowing it to furnish further service in the direction of more and improved lighting.

Lighting of Speed Limit Signs

These small signs located on main highways at the corporate limits of villages and towns may be very effectively lighted by means of an angle reflector, a small 1:1 ratio SL transformer, and a 1000-lumen series lamp. By putting this equipment on a regular street lighting circuit for lamps, the speed limit sign may be turned on and off simultaneously with the regular street lamps, thus requiring no attention on the part of the central station, with the exception of maintenance and lamp renewals. In order to obviate the danger of high voltage wires in the proximity of pedestrians, it is necessary to install the SL transformer close to the series circuit, and run low voltage leads from the secondary of the insulating transformer to the reflector.

Lighting of Billboards and Poster Panels

It will usually be found that there are many localities along highways where street lighting circuits are the only ones available. If the localities are not built up to such an extent that commercial

service is provided for, the street lighting circuit may advantageously serve illuminated outdoor advertising. There are signs along the road, extolling the virtues of chewing gum, tobacco, cigarettes, etc., that have absolutely no advertising power at night unless illuminated. Heretofore these signs have been dark after sundown. There is no reason why they should not tell their story more effectively at night since illumination renders them more conspicuous than does daylight. The advertiser would be bene-

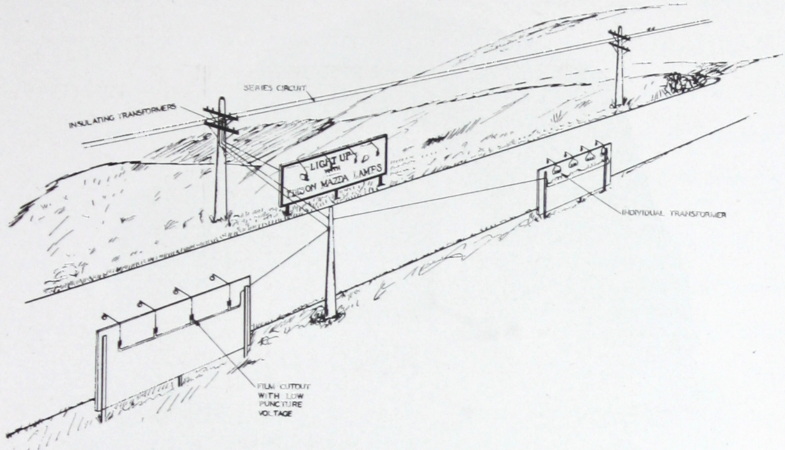
Poster panels and signs by the roadside may be lighted by lamps connected to the regular lighting circuits. The above is an illustration of a warning sign for motorists erected in a suburban town.

fited; the public would have its attention drawn more frequently to the product. The electric service company would be benefited by increasing the utility of its street lighting circuit, creating an additional load without the necessity of any line extension, and by increasing the load factor of its lines (by building up the valley of the curve, since this is an all-night load).

These poster panels are of standard length, usually 25 feet. Four angle reflectors equipped with mogul sockets and 1000-lumen series lamps will light a panel to a sufficiently high level.

Each lamp may be put on the secondary of an individual transformer, the four individual transformers being in series on the secondary of a larger insulating transformer.

If an individual transformer is not desired it would be possible to use a prong socket and receptacle (external to the reflector and bracket), equipped with a film cutout that will puncture at approxi-



Diagrammatic representation of the connections for illuminating bulletin boards from the regular highway series circuit. Two methods of wiring are indicated, the board at the left having lamps in series with a film cutout over each, while the lamps on the right hand board are fed from individual series transformers.

mately 40 to 60 volts. This equipment is shown diagrammatically in the illustration.

Floodlighting

The floodlighting of traffic officers who are stationed at important intersections has been attempted frequently with decided success. There are available transformers having a series primary and a multiple or constant voltage secondary. In this way a projector with a multiple lamp may be used. The projector is usually located on top of a nearby pole and directed at the spot where the officer stands.

Billboards and poster panels may be lighted by projectors equipped with either multiple or series lamps, and the proper type of transformer. If this method is attempted, precaution must be taken that there be no spilled light that might prove objectionable;

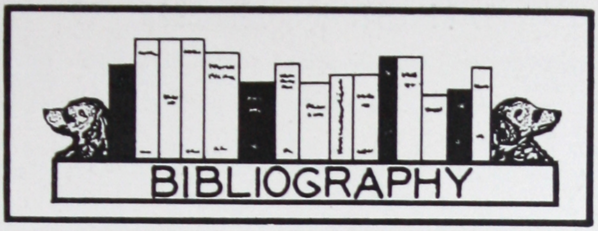
that there be no reflected glare from the panel; and that motorists are not subjected to the beam of the projector.

The floodlighting of buildings of any considerable size usually entails such a large wattage that the reserve capacity of the series circuit may not be sufficient to supply the demand. If, however, this item can be taken care of, and poles can be mounted in the proper position, there is no reason why floodlighting cannot be

An increasing use of the regular lighting circuits is found in the application of these for the illumination of memorials of historic interest. The Edison Memorial at Menlo Park, N. J., is lighted in this manner, and attracts the attention of travelers on one of the main highways between New York and Philadelphia.

accomplished in this manner. In fact, several successful jobs have been handled in this way.

It must be borne in mind when using series lamps that the light center length must be the same as the light center length of the lamp for which the projector was designed. Otherwise, the beam may be altered to such an extent that there is no provision for beam control.



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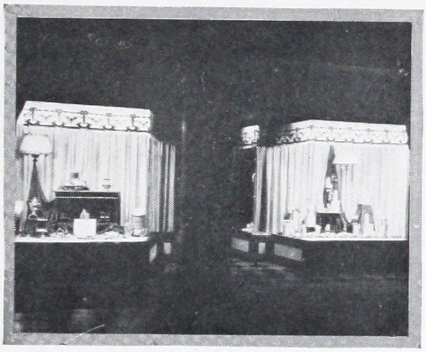
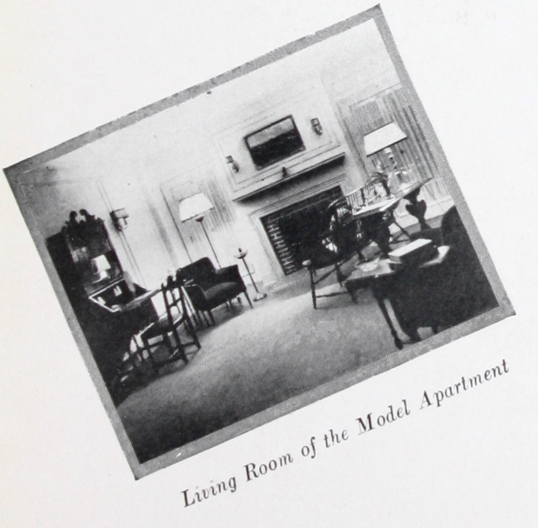
Auditorium, Showing Miniature Stage and Specially Designed Lighting Units



Model Show Windows



Living Room of the Model Apartment

Street Lighting Exhibit

Individuals or groups are always welcome. The Institute is open from nine to five every week-day except Saturday. Special arrangements may be made for groups at night. Further details regarding the Institute may be obtained and arrangements for visits made by writing the Edison Lighting Institute, Edison Lamp Works of the General Electric Co., Harrison N. J., or by telephoning Harrison 8000, extension 380.

Visit the Edison
Lighting Institute
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